ATTACHMENT 4

Southern California Edison Company, El Segundo Generating Station 316 (B) Demonstration. Prepared for California Regional Water Quality Control Board, Los Angeles Region. Dated September 20, 1982

SOUTHERN CALIFORNIA EDISON COMPANY
EL SEGUNDO GENERATING STATION
316(b) DEMONSTRATION

Prepared for

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
LOS ANGELES REGION

20 September 1982

SOUTHERN CALIFORNIA EDISON COMPANY
Rosemead, California

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EXECUTIVE SUMMARY

1. Southern California Edison Company (SCE) prepared this demonstration document to satisfy requirements of Section 316(b) of the Federal Water Pollution Control Act of 1972 (PL 92-500). Section 316(b) requires "... that the location, design, construction, and capacity of cooling water intake structures reflect the best technology available for minimizing adverse environmental impact."

2. El Segundo Generating Station (ESGS) consists of four base load steam electric generating units with a combined capacity of 1,020 MW. Units 1 and 2 share a common once-through cooling system having a flow of 144,000 gpm (9.1 m^3/sec) with a submerged offshore intake. Units 3 and 4 share a common once-through cooling system having a flow of 263,400 gpm (16.6 m^3/sec) with a submerged offshore intake. Both intakes have velocity caps installed to minimize the entrapment of fish.

3. A 316(b) Study Plan, accepted in April 1979 by the California Regional Water Quality Control Board, Los Angeles Region, and the California Department of Fish and Game, detailed an approach and methodology for determining best technology available in compliance with Section 316(b). The approach included rationale for selective studies at representative sites applicable to other similar SCE systems, methodology for biological and physical/hydraulic studies, and a list of fish species targeted for extensive analysis.

4. Hydraulic and design evaluations were conducted at ESGS intakes, and observations of impingement of juvenile and adult fishes were recorded. ESGS was grouped with other similar intake systems as part of the representative site approach. Ormond Beach Generating Station was the site chosen for sampling of entrainment of fish larvae for this group. Those sampling results, adjusted for the difference in flow, were used in the assessments for ESGS. Fish losses were related to the dynamics of nearshore populations, and an evaluation of the relative effectiveness of alternative intake technologies was conducted. A total of 28 alternative intake designs were evaluated for applicability to the existing cooling water systems, but only 9 were determined to be feasible for use at ESGS. Cost of installation was not utilized as an initial criterion to eliminate any technology from further consideration.

5. This document presents an evaluation of physical and biological effectiveness of the existing ESGS cooling water intake systems and the other alternate intake designs based on an Impact Assessment Model, which is detailed in the 316(b) Demonstration Technical Appendix. The model utilizes specific loss inputs for the generating station (entrainment and impingement of larval and adult fishes) in comparisons with estimates of nearshore field populations. An evaluation of intake technologies is incorporated into the Impact Assessment Model, allowing a comparison of cost and biological effectiveness of the nine alternate intake configurations applicable to ESGS.

6. Entrainment of fish larvae was dominated by several 316(b) target species, including northern anchovy, white croaker, and queenfish. Impingement catch was dominated by queenfish, white croaker, walleye surfperch, white surfperch and shiner surfperch.

7. A statistic denoting percent probability of survival of each fish of each species (R_c) was developed from the Impact Assessment Model. Values of percent probability of mortality ($1-R_c$) due to operation of the ESGS with its present velocity cap technology indicated that in no case was more than 0.8% of any fish species population affected. In most cases the calculated probability was a small fraction of one percent, and the impact on all 15 target species examined was determined to be insignificant.

8. Based on conceptual engineering designs for application of the nine technologies to each of the two ESGS intakes, the costs of applying technologies beyond the existing velocity caps range between $1.0 and $97.7 million for each intake. The incremental improvements in survival for alternative technologies compared to the existing velocity cap were all less than 0.7%, with the majority less than 0.3%.

9. The existing intakes utilizing velocity cap technology are concluded to be best technology available. This determination is based on: 1) the ESGS does not have a significant adverse effect on the nearshore fish populations in the Southern California Bight; and 2) since probabilities of survival for all species were greater than 99.2% with the current velocity cap configuration, the existing intakes currently minimize any adverse impact, and the costs to achieve the extremely small incremental improvements in survival are not justified.

SOUTHERN CALIFORNIA EDISON COMPANY
EL SEGUNDO GENERATING STATION
316(b) DEMONSTRATION

I. INTRODUCTION

Southern California Edison Company (SCE) prepared this demonstration document to satisfy requirements of Section 316(b) of the Federal Water Pollution Control Act of 1972 (PL 92-500). Section 316(b) states that "Any standard established pursuant to section 301 or section 306 of this Act and applicable to a point source shall require that the location, design, construction, and capacity of cooling water intake structures reflect the best technology available for minimizing adverse environmental impact."

HISTORICAL BACKGROUND

SCE 316(b) Study Plan

In April 1979, SCE submitted to the California Regional Water Quality Control Board, Los Angeles Region (CRWQCB), a 316(b) Program Study Plan (SCE 1979), detailing an approach to determine best technology available. The Study Plan, a cooperative effort of SCE, the California Department of Fish and Game, the State Water Resources Control Board, and three Regional Boards, outlined methodology for completion of intake technology engineering and biological effectiveness evaluations, determination of available fishery stocks, estimates and effects of station cooling water system losses, and, finally, an analysis of best technology available. The plan included an evaluation of the representative site concept and a list of species targeted for analysis. The effect of intake losses of phytoplankton and zooplankton on endemic populations was determined to be undetectable, and these organisms were not included in the proposed list of target organisms (Sowby et al. 1979). The 316(b) Program Study Plan was approved by the CRWQCB, and preparation of the 316(b) demonstration for El Segundo Generating Station (ESGS) was initiated.

For this evaluation of ESGS, a database of biological information was developed. Hydraulic ~~and design~~ evaluations were conducted at each ESGS intake, and observations of impingement of juvenile and adult fishes were recorded. Fish losses were related ~~to the~~ dynamics of nearshore populations, and an evaluation of the relative effectiveness of alternative intake technologies was conducted. A total of 28 alternative intake designs were evaluated for applicability to existing cooling water systems, but only 9 were determined to be feasible for use at ESGS. Cost of installation was not utilized as an initial criterion to eliminate any technology from further consideration. The best technology available was determined from indices of physical and biological effectiveness as well as costs of each technology.

Representative Site Concept

The SCE system consists of six intakes in offshore marine waters and seven in protected harbors. However, many of these intakes have similar design characteristics, and the biological habitat surrounding the area of the intakes is frequently similar due to siting requirements.

A physical and biological characterization of SCE cooling water intakes was conducted to identify representative sites for intensive study (Schlotterbeck et al. 1979). The investigation identified five groups of intakes with similar characteristics. One intake from each of these groups was used as representative of all intakes in that group for determination of entrainment of fish larvae. Impingement sampling of juvenile and adult fishes was conducted at each cooling water intake system. The impact of cooling system entrainment (SCE 1982a) and impingement on fishery resources was determined by comparison of losses to available fishery stocks, which were estimated from offshore collections of ichthyoplankton (Lavenberg and McGowen 1982) or estimates of adult fishery stocks from several years of National Pollutant Discharge Elimination System [NPDES] and/or Environmental Technical Specifications monitoring at SCE system stations. Ormond Beach Generating Station was the representative site for entrainment sampling for the group of similar intakes with which ESGS was classified (Schlotterbeck et al. 1979). Entrainment losses at ESGS were estimated using data from Ormond Beach, adjusted for flow volume differences.

316(b) Target Species

Target species were selected in consultation with the CRWQCB and the California Department of Fish and Game on the basis of potential effects on their abundance and distribution. Criteria established for selection of key species included: 1) importance in the trophic structure (either as planktivorous, piscivorous, or benthic feeders, and importance as a prey food source); 2) presence in the source body with at least minimal abundance during most periods of the year to lend statistical integrity to analyses; 3) species subject to entrainment and impingement during most of their life history; 4) species which, if adversely impacted, may indicate general community effects; and 5) sport or commercial value. An evaluation of species was conducted (Wintersteen and Dorn 1979), and the final list included 15 species:

Northern anchovy	*Engraulis mordax*
Queenfish	*Seriphus politus*
White croaker	*Genyonemus lineatus*
White surfperch	*Phanerodon furcatus*
Shiner surfperch	*Cymatogaster aggregata*
Walleye surfperch	*Hyperprosopon argenteum*
Pacific butterfish	*Peprilus simillimus*
Kelp bass	*Paralabrax clathratus*
Barred sand bass	*Paralabrax nebulifer*
Sargo	*Anisotremus davidsonii*
Spotfin croaker	*Roncador stearnsii*
Bocaccio	*Sebastes paucispinis*
Black surfperch	*Embiotoca jacksoni*
Yellowfin croaker	*Umbrina roncador*
Black croaker	*Cheilotrema saturnum*

CONTENT OF THE EL SEGUNDO 316(b) DEMONSTRATION DOCUMENT

The ESGS 316(b) document presents a description of the generating station location, plant operation, and design and configuration of the cooling water system. The hydrology and physical and chemical characteristics of the receiving waters in the area near the station are discussed. Fish species commonly observed in the vicinity of the generating station are shown to be representative of populations throughout the Southern California Bight.

Estimated entrainment of larval fishes (from representative site data) and impingement of adult fishes (from ESGS operating data) are presented to quantify the losses to the fishery resource. An impact assessment is presented that compares station losses to available Bight stocks by means of an Impact Assessment Model.

A total of 28 alternative intake technologies were evaluated for applicability to the two ESGS intakes. Criteria for the selection of the alternatives discussed in this report were: 1) demonstrated operational reliability for this particular environmental setting; 2) biological effectiveness; and 3) engineering feasibility. The index of biological effectiveness and results of the evaluation of physical compatibility were utilized to compare potential minimization of biological impact with installation costs at each intake site. A final conclusion of best technology available is made on the basis of possible benefit against reasonable cost of installation.

Technical Appendix

The 316(b) Demonstration Technical Appendix (SCE 1982b) serves as a detailed description of the database and methodologies used to develop the Impact Assessment Model for evaluation of generating station effects on source water fish stocks. Rationale for selection of the Southern California Bight as the source water body for the model database is developed. The Appendix also presents methodology and results for calculation of entrainable and impingeable larvae and adults from estimates of offshore resources.

II. DESCRIPTION OF THE GENERATING STATION

CIRCULATING WATER SYSTEM DESCRIPTION

El Segundo Generating Station is located on Santa Monica Bay within the City of El Segundo (Figure II-1). The station consists of four steam electric generating base load units. Units 1 and 2 are each rated at 175 MW (net) and utilize a seawater cooling system with an offshore intake. Units 3 and 4 are each rated at 335 MW (net) and utilize a seawater cooling system and offshore intake which is independent from Units 1 and 2 (LMS 1979).

Units 1 and 2

System Description

The circulating water system for ESGS Units 1 and 2 is represented in Figures II-2 through II-5. The cooling water for Units 1 and 2 enters an intake structure located 2,289 ft (697 m) offshore at a depth of 32 ft MLLW (9.8 m). A cap supported by legs 2.0 ft (0.6 m) above the intake forces the entrained water to flow in a horizontal direction at an average velocity of 2.4 fps (0.7 m/sec) at the point of withdrawal (Figure II-2). The circulating water flow of 144,000 gpm (9.1 m^3/sec) is conveyed to the Units 1 and 2 onshore screenwell structure through a single 10 ft (3.0 m) inside diameter concrete conduit at a velocity of 4.1 fps (1.2 m/sec).

Water enters the screenwell structure, passes through trash bars which remove large debris, and then through four traveling screens which remove smaller debris. The calculated mean velocity approaching the screens is 0.8 fps (0.24 m/sec), and 1.8 fps (0.54 m/sec) through the screens. (Actual velocity was measured and varied considerably from the mean value as discussed below.)

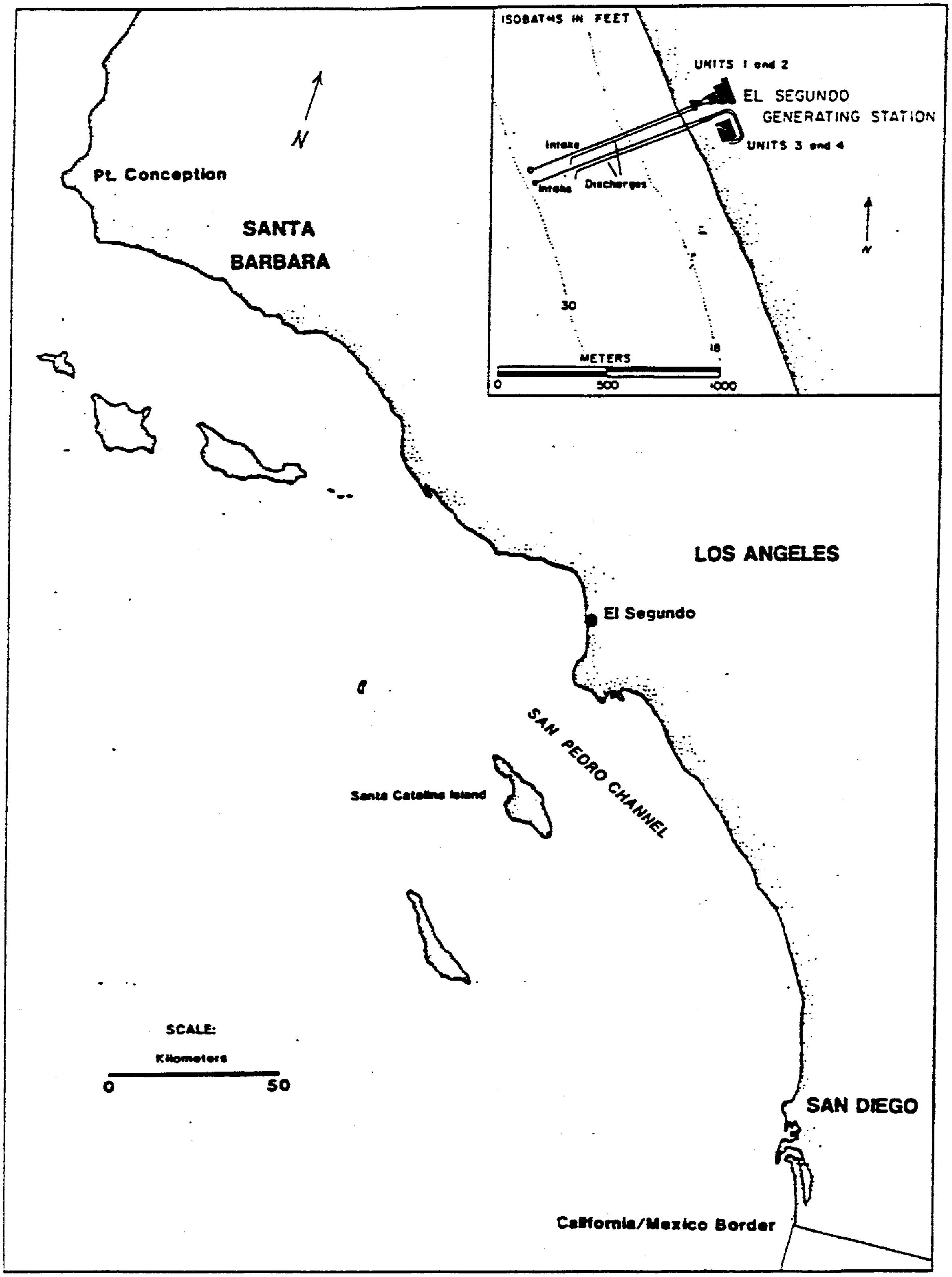

Figure II-1. Location of the El Segundo Generating Station on the southern California coast, and placement of the cooling system intake and discharge conduits (inset).

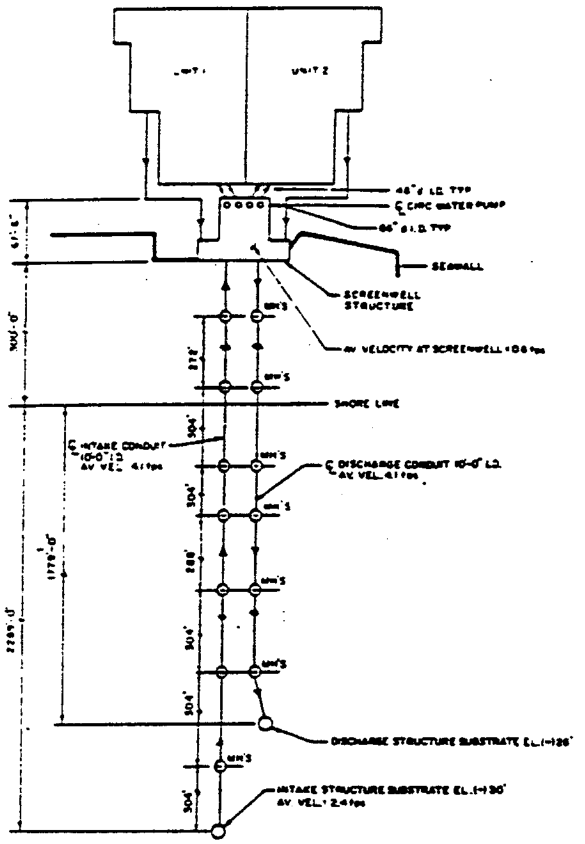

Figure II-2. El Segundo Generating Station Units 1 and 2 circulating water system.

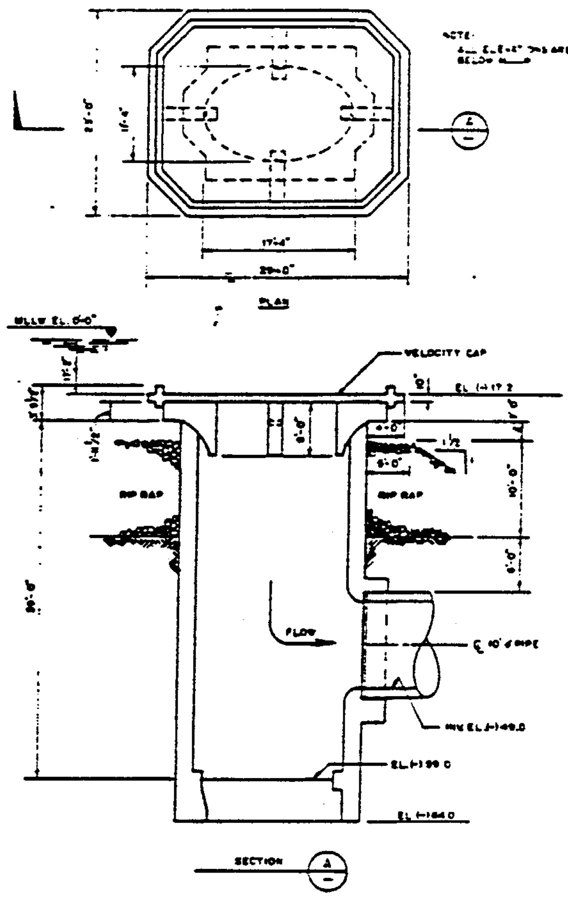

Figure II-3. El Segundo Generating Station Units 1 and 2 offshore intake structure.

Water is drawn through the screens by four vertical wet pit type circulating pumps. These four pumps supply 137,000 gpm (8.6 m^3/sec) to the main condensers and 7,000 gpm (0.4 m^3/sec) to auxiliary heat exchangers for plant equipment cooling functions.

Water flows from the pumps to the main condensers through four 4 ft (1.2 m) inside diameter (I.D.) pipes at a velocity of 6.4 fps (2.0 m/sec). Passing through the condenser tubes at a velocity of 7.0 fps (2.1 m/sec), the water temperature is raised 23.7°F (13.2°C). Water from each condenser returns to the discharge through a 5.5 ft (1.7 m) inside diameter pipe at a velocity of 6.7 fps (2.0 m/sec), where the flows from each condenser join to return to the ocean through a 10 ft (3 m) I.D. pipe at a velocity of 5.1 fps (1.6 m/sec). The total water transit time, from offshore intake to discharge, is 21.5 minutes.

Velocity measurements were conducted in the Units 1 and 2 screenwell to define the hydraulic characteristics of the structure. The structural features of the intake most significantly influencing the internal hydraulics are the off-center location of the intake conduit entrance to the trash rack bay and the lack of sufficient distance in the forebay for the inlet jet to expand and dissipate before contacting the screens.

Velocity Measurements

Velocities were measured along horizontal and vertical transects over the face of each vertical traveling screen. At each location both the perpendicular

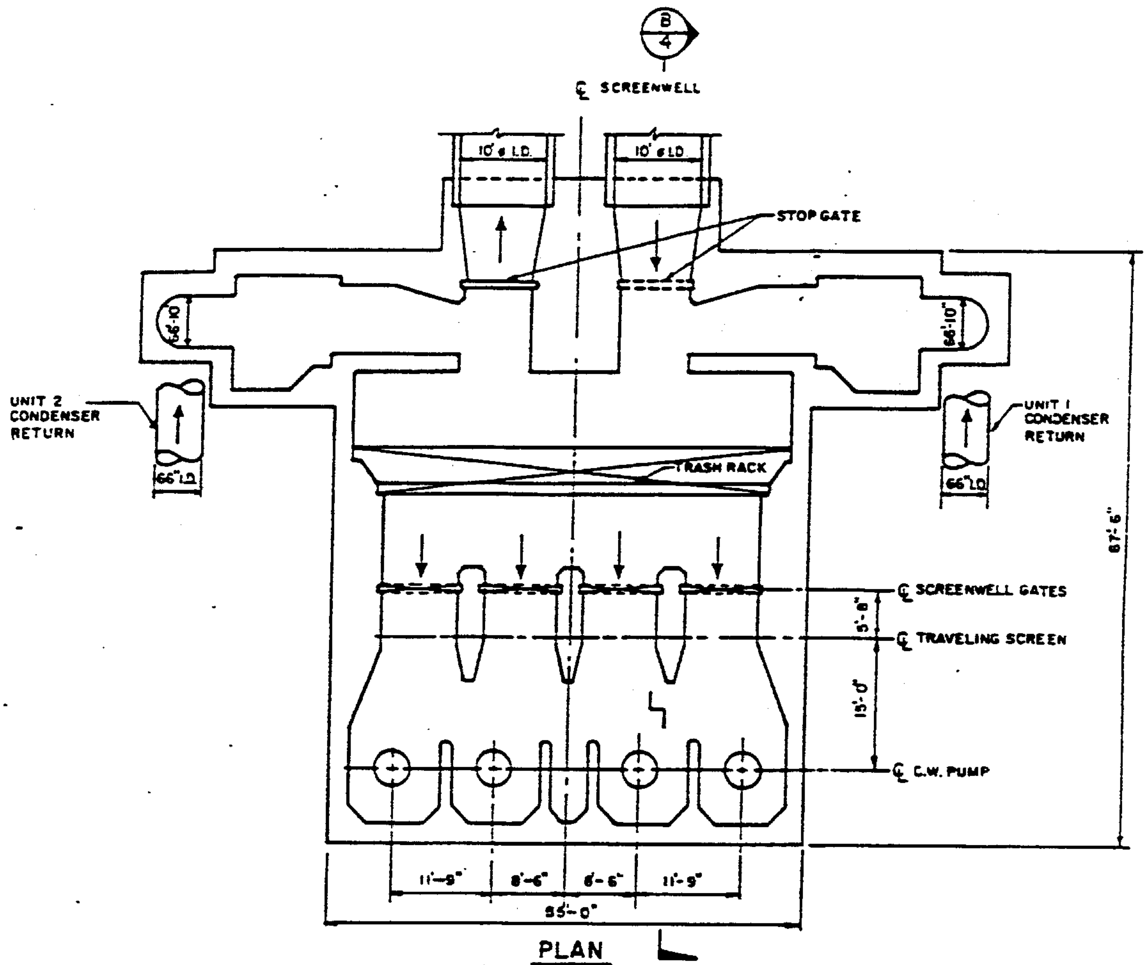

Figure II-4. El Segundo Generating Station Units 1 and 2 screenwell structure (overhead view).

and lateral component of velocity were measured (Table II-1 and Appendices II-1 through II-4). Two characteristics dominate the velocity distributions: 1) the variation in average screen velocity between screens; and 2) the significant quantity of backflow (negative velocity) observed on the two central screens.

The variation in the average perpendicular components among the four screens was a result of the off-center location of the intake conduit inlet to the trash bar bay. The screen with the highest average velocity (1.3 fps [0.4 m/sec]), Screen 2, is located directly across from the inlet conduit (Figure II-4), where water entered the bay at a calculated average velocity of 4.1 fps (1.2 m/sec). The variation of the average lateral components for each of the four screens showed the same pattern observed in the perpendicular component, with the highest lateral component (1.6 fps [0.5 m/sec]) associated with Screen 2 and the lowest (-0.02 fps [-0.01 m/sec]) associated with Screen 4. This trend was also partially attributed to the location of the screens relative to the intake conduit, although it is additionally influenced by the pumpwell configuration.

The second major feature of the velocity distributions, shown in Appendices II-1 through II-4, was the degree of variation across each of the individual screens. Each showed substantial lateral variation in the perpendicular velocity component, with varying degrees of backflow occurring on Screens 1 through 3.

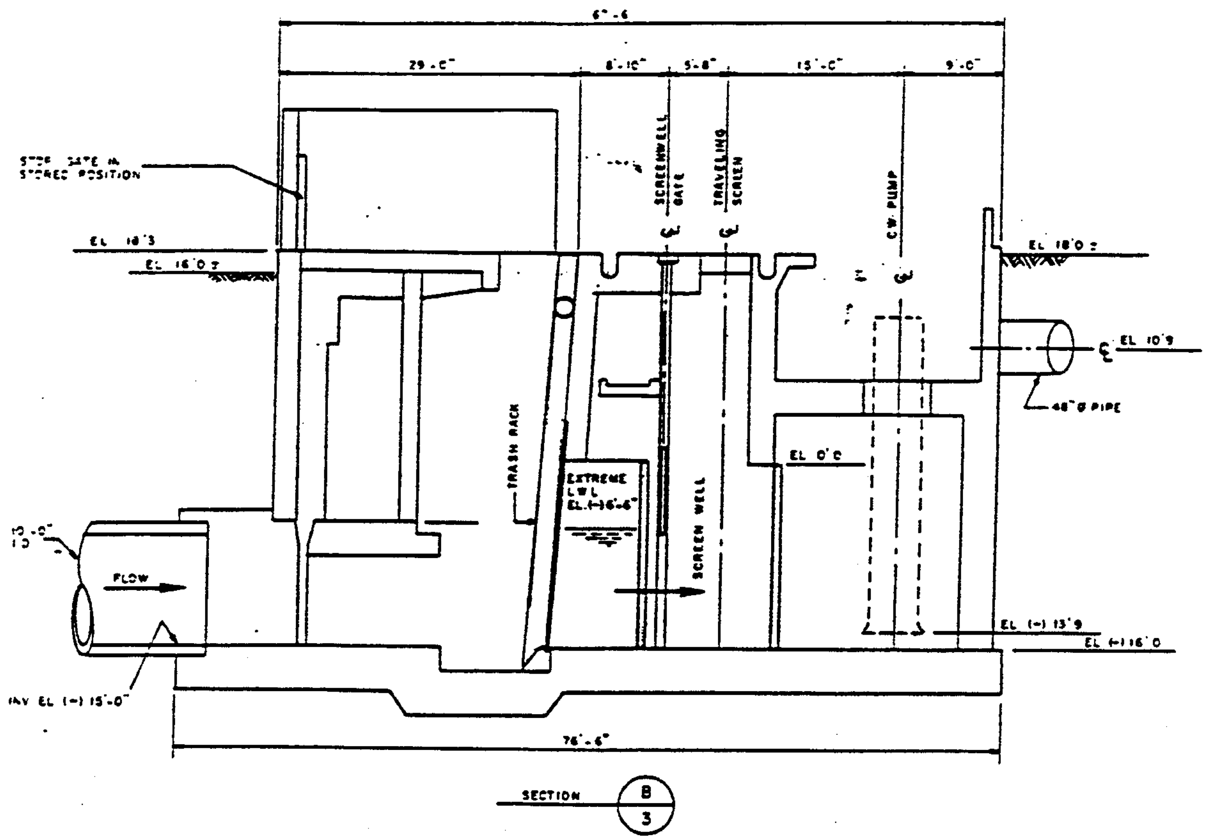

Figure II-5. El Segundo Generating Station Units 1 and 2 screenwell structure (side view).

Table II-1. El Segundo Generating Station Units 1 and 2 screenwell velocity measurements (30 August 1978, 1200-1600 hrs).

Depth (ft)	Velocity* (fps)					
	Screen 1 (North)			Screen 2		
0						
2	0.00	0.02	0.74	0.24	1.08	-0.80
6	-0.04	0.04	2.76	4.52	3.84	-1.30
10	-0.28	2.48	-0.36			
14	0.10	1.46	3.64			
Mean		0.88			1.26	
Tide**		+2.8			+2.0	
	Screen 3			Screen 4 (South)		
0						
2	0.14	1.00	1.00	0.16	0.49	0.63
6	-0.28	0.38	0.94	0.14	0.52	0.72
10	0.18	1.10	1.04	0.03	0.33	0.63
12	-0.10	1.12	0.76	0.26	0.37	0.46
Mean		0.61			0.40	
Tide**		+2.2			+3.6	

* Values shown represent mean of readings taken at 10-second time constant.
** 0.0 = MLLW

The lateral distributions were the result of the combined effects of the location of the intake conduit and the location of the pumpwells relative to the traveling screen channels (Figure II-4). The pumpwells are offset from the screen channels (Figure II-4), which, in the absence of other influences, would be expected to cause the pumps to draw higher flows through the side of each screen closest to the pump.

In the case of Screen 2, the two influences were additive, in that the highest inlet jet effect occurred on the same side of the screen as the pump offset effect. On Screen 1 however, the inlet jet effect forced a sufficient flow rate through the south side of the screen to nullify the effect of the pump offset to the north. The dominance of the jet effect over the pump effect on Screens 1 and 2 was further indicated by the occurrence of reverse flow on the side of the screen opposite the side with high inflow velocities.

Both the maximum short duration velocities observed on each of the four screens and the maximum average velocities at individual points followed the same pattern as the screen face averages. Screen 2 (Appendix II-2) showed average 1-second velocities of 6.0 fps (1.8 m/sec) and maximum 10-second average velocities in excess of 4.5 fps (1.4 m/sec) at individual points. These values were approximately ten and seven times the calculated average velocity of 0.6 fps (0.3 m/sec), if evenly distributed flow across all four screens is assumed. By contrast, maximum short duration velocities at Screen 4 exceeded 1.0 fps (0.3 m/sec) at only one grid point, and the maximum 10-second average velocity was 0.7 fps (0.2 m/sec).

In summary, velocity measurements indicated the location of the intake conduit and the offset positioning of the circulating water pumps combined to cause dramatic lateral variations in velocity across individual screenfaces and flow variations between screens. Visual observations during the survey confirmed high levels of turbulence and back flow at both the traveling screens and the trash racks. These effects resulted in velocities of up to 6.0 fps (1.8 m/sec), or ten times the calculated mean value to occur at some locations.

These velocity patterns are important in evaluating alternative intake technologies which have narrow design requirements to achieve rated effectiveness.

Units 3 and 4

System Description

The Units 3 and 4 circulating water system is shown in Figures II-6 through II-9. The water for Units 3 and 4 enters a vertical intake structure located 2,300 ft (701 m) offshore at a depth of 32 ft MLLW (9.8 m). This structure has a velocity cap similar to Units 1 and 2 (Figure II-7). The circulating water flow of 276,800 gpm (17.5 m^3/sec) is conveyed to the Units 3 and 4 onshore screen structure through a single 12 ft (3.7 m) inside diameter concrete conduit at a velocity of 5.5 fps (1.7 m/sec).

The Units 3 and 4 screenwell structure (Figures II-8 and II-9) is different from the Units 1 and 2 structure in that the intake conduit is centered at entry to the forebay, and a gradual expansion zone is provided prior to encounter with the trash racks. The calculated approach water velocity is 0.8 fps (0.2 m/sec), and velocity through the screen is 2.0 fps (0.6 m/sec) at mean water level.

Water flows from the screens to four horizontal type centrifugal pumps with vertical suction pipes removing water from a wet sump. These pumps supply 263,400 gpm (16.6 m^3/sec) to the main condensers and 13,400 gpm (0.8 m^3/sec) to auxiliary heat exchangers.

Water flows from the pumps to the two main Units 3 and 4 condensers through four 5.5 ft (1.7 m) I.D. pipes at a velocity of 6.2 fps (1.9 m/sec). Passing through the condenser tubes water temperature is raised 22°F (14.3°C). The discharge from Unit 4 condenser flows through a 8 ft (2.4 m) I.D. pipe at a velocity of 5.9 fps (1.8 m/sec) until it joins the flow from Unit 3 condenser, and then the combined discharges flow through an 11 ft (3.4 m) I.D. pipe at a velocity of 6.2 fps (1.9 m/sec) to the discharge chamber adjacent to the

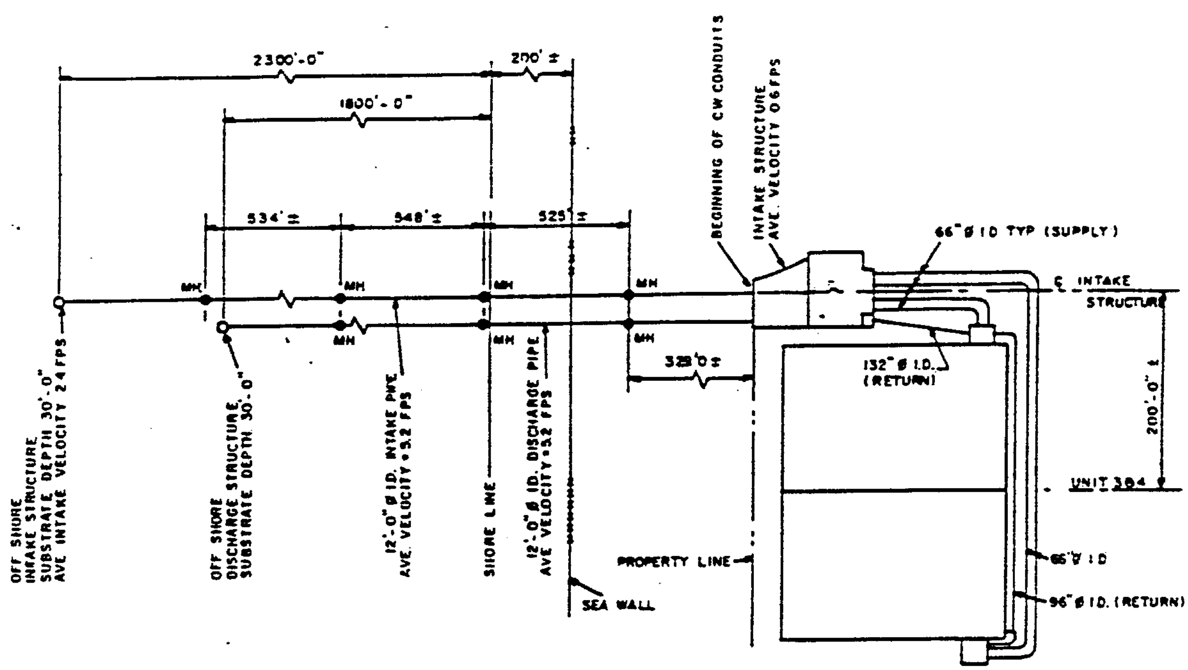

Figure II-6. El Segundo Generating Station Units 3 and 4 circulating water system.

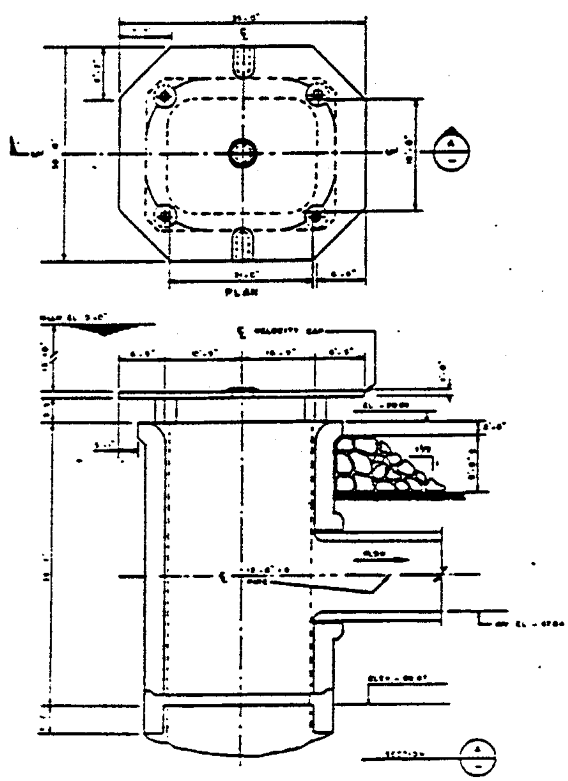

Figure II-7. El Segundo Generating Station Units 3 and 4 and offshore intake structure.

screenwell (Figure II-8). Water is returned to the ocean through a 12 ft (3.7 m) I.D. conduit at a velocity of 5.5 fps (1.7 m/sec) and discharged through a vertical riser. The total water transit time from intake to discharge is 21.1 minutes.

Velocity Measurements

Velocity measurements were conducted at Units 3 and 4 in front of the traveling screens. Measurements were made over a grid of three horizontal positions at three depths on each screen.

The results of the velocity measurements at ESGS Units 3 and 4 are provided in Table II-2 and Appendices II-5 through II-8. With the exception of Screen 2, results showed low variation of the perpendicular velocity component in either the vertical or horizontal dimension on each screen. The majority of the 1.0 and 10.0 second average values fall between 0.9 and 1.1 fps (0.3 m/sec). Screen 2 showed the highest degree of variation with both 1.0 and 10.0 second averages exceeding 1.6 fps (0.5 m/sec) at the mid-depth location on

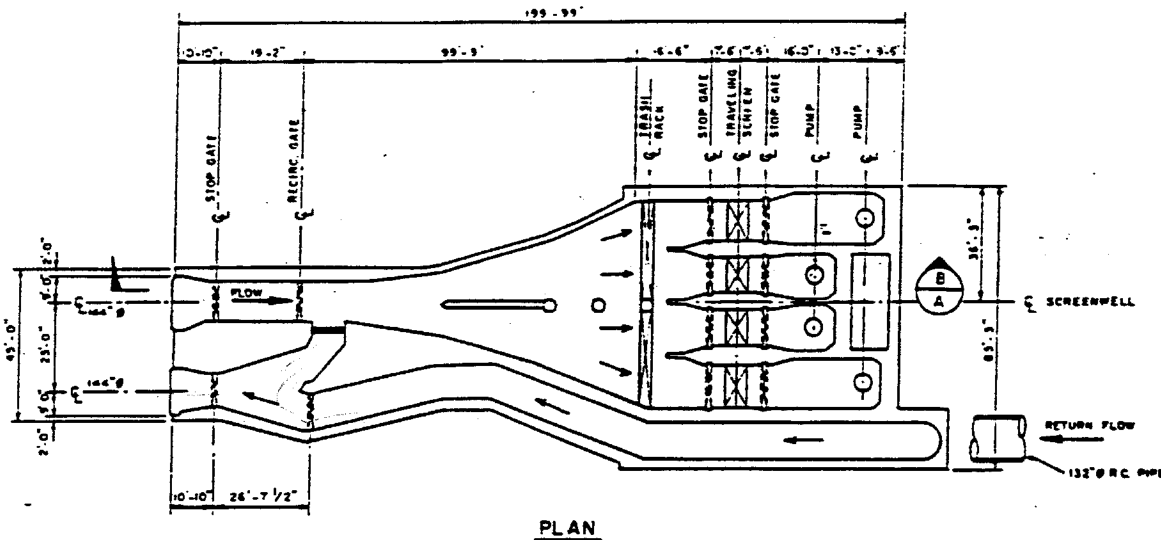

Figure II-8. El Segundo Generating Station Units 3 and 4 screenwell structure (overhead view).

the south side of the screen relative to the screen face averages of 1.0 and 1.1 fps (0.3 m/sec) for the two time constants. The highest instantaneous velocities (2.4 fps [0.8 m/sec]) were also observed at this location.

A comparison of the four screen face average values for the perpendicular velocity component also showed low variation among the four screens (less than ± 10% of the four screen mean value of 1.0 fps [0.3 m/sec]). Examination of the standard deviations associated with both the 1.0 and 10.0 second time constant readings consistently indicated deviations less than 30% of the mean value at each measurement point. Because the upper and lower values for the ranges of velocity at each point were consistently within +50% of the mean values (except Screen 2), all the above results indicated the low levels of fluctuations in velocity and the lack of turbulence. The turbulence indicated by the velocity data near the south side of Screen 2 was also observed visually during the

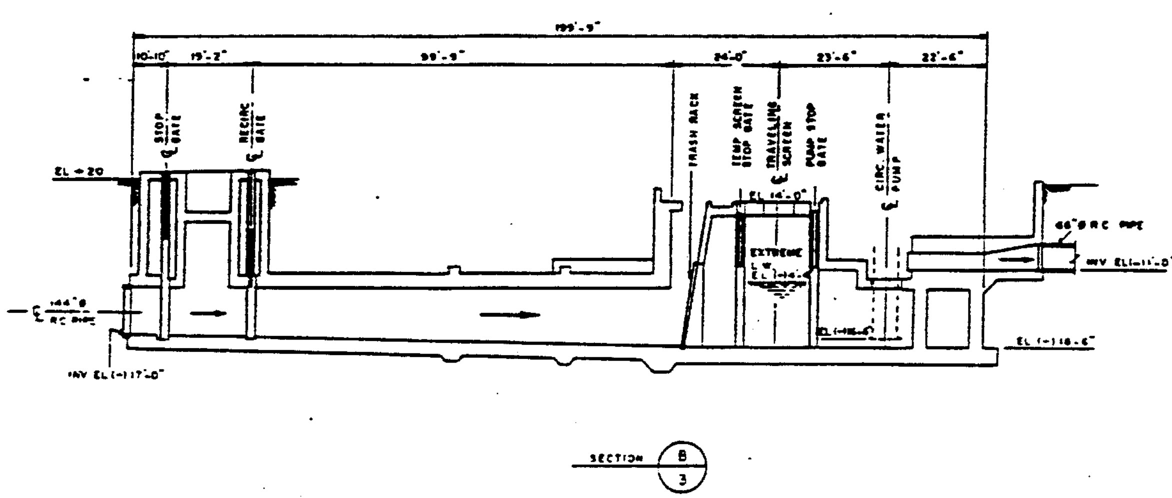

Figure II-9. El Segundo Generating Station Units 3 and 4 screenwell structure (side view).

Table II-2. El Segundo Generating Station Units 3 and 4 screenwell velocity measurements (14 November 1978, 1400-1800 hrs).

Depth (ft)	Velocity* (fps)					
	Screen 1 (North)			Screen 2		
0						
2	0.88	0.80	0.92	0.80	0.32	1.54
6	1.02	0.92	0.84	1.12	1.48	1.62
10	0.98	0.98	0.76	0.54	1.14	1.16
Mean		0.90			1.08	
Tide**		0.5			0.0	
	Screen 3			Screen 4 (South)		
0						
2	1.02	0.94	1.18	0.86	1.12	1.10
6	0.92	0.92	1.12	1.10	1.08	1.08
10	0.80	1.14	1.20	0.80	1.00	0.94
Mean		1.03			1.01	
Tide**		-0.5			-0.5	

* Values shown represent mean of readings taken at 10-second time constant.
** 0.0 = MLLW

measurements and appeared to be associated with either the center dividing wall at the trash racks (Figure II-8) or incomplete spreading of the centered inlet conduit jet.

The even flow pattern was further substantiated by the low (generally less than 1.6 fps [0.5 m/sec]) average values of the lateral component of velocity on all screens, except Screen 2 where higher lateral components were associated with the previously described higher perpendicular components.

The even flow distribution was attributed to the expansion zone upstream of the screens which allowed the flow from the 12 ft (3.7 m) diameter inlet tunnel to spread both horizontally and vertically. The difference in the flow distributions observed at the Units 1 and 2 intake, with no expansion section, and at the Units 3 and 4 intake, with the expansion section, clearly indicated the turbulence-reducing effect of the expansion zone. The effect of the observed differences in screenwell flow patterns at Units 1 and 2 and Units 3 and 4 on alternative intake technology evaluations will be discussed further in Chapter VI.

DESCRIPTION OF STUDY AREA

The El Segundo Generating Station is located on Santa Monica Bay, a coastal area of the Southern California Bight (Figure II-1). Located 0.4 miles (0.6 km) to the north-northwest of the generating station is the Standard Oil Company of California El Segundo Refinery. Approximately 450 m further upcoast is the Hyperion Sewage plant. Scattergood Generating Station (Los Angeles Department of Water and Power) is located one mile upcoast of ESGS. Further upcoast is the entrance to the Marina del Rey harbor and the mouth of Ballona Creek. South (downcoast) of the generating station is the Manhattan Beach pier.

Topography

The general orientation of the Southern California Bight coastline between Point Conception and the Mexican border tends from northwest to southeast. The continental margin of the Bight emerged slowly over a long geological period, resulting in a predominantly cliffed coastline, broken by coastal plains in the Oxnard-Ventura, Los Angeles, and San Diego areas. The coastal region is drained by many small streams which normally flow only during rain storms. Only a small part of the storm runoff ever reaches the ocean because most is impounded by dams and/or diverted for other uses.

Eight islands offshore of southern California strongly influence water circulation and oceanographic characteristics of the coastal region. The mainland shelf is narrow along the coast, ranging from approximately 1.6 to 19 km in width, and averaging nearly 7 km. Seaward of the shelf is a geologically complex region known as the continental borderland, which is comprised of basins and ridges extending from near the surface to depths in excess of 2,400 m.

Climate

Southern California lies within a Mediterranean climatic regime characterized by short, mild winters and warm, dry summers. Annual precipitation near the coast averages about 46 cm, of which 90% occurs between November and April.

In summer, sea breezes combine with the prevailing northwest winds to produce strong onshore winds. In late fall and winter, pressure systems frequently form which tend to produce coastal winds from the southeast between November and February. Monthly mean air temperatures along the coast range from 8.3°C in winter to 20.6°C in summer.

Currents

Northern Pacific Ocean waters driven eastward by prevailing westerly winds impinge on the western coast of North America, divide, and then flow both north and south. The southern component is the California Current, a meandering southeastward flowing water mass. There is no defined western boundary of this current, but more than 90% of the southeastward transport is within 725 km of the California coast. The current diverges south of Point Conception, with one branch turning northward inshore of the Channel Islands and thus forming the inner edge of the Southern California Countercurrent. Surface speed in the countercurrent averages between 3 to 6 m/min. The flow pattern in the Channel Islands region fluctuates seasonally, and is more developed in summer and autumn, and weak or occasionally absent in winter and spring. The average surface water circulation off southern California is shown in Figure II-10 (after Jones 1971).

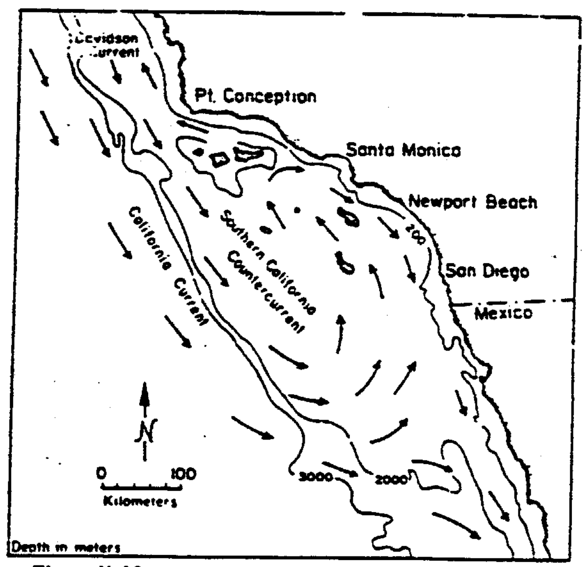

Figure II-10. Average surface water circulation off southern California (after Jones 1971).

Local currents near the California coast are influenced by a combination of wind, tide and topography. Wind-induced currents, which are superimposed on tidal motion, usually have a strong diurnal component in response to local wind patterns. Therefore, short term observations of currents near the coast often vary in both direction and speed as a result of combined wind-induced and tidal motions.

Tides

Tides along the California coast are mixed, with two unequal highs and lows occurring during each 25 hr period. The tide is a long-period wave that is a cumulative product of semidiurnal components with 12 hr periods, plus diurnal components with nearly 25 hr periods. In the northeastern Pacific Ocean, the tide wave rotates in a counterclockwise direction such that flood tide currents flow upcoast and ebb tide currents flow downcoast.

Upwelling

Predominant northwesterly winds are responsible for large scale upwelling along the California coast between February and October. Upwelled water is colder, more saline, lower in dissolved oxygen and higher in nutrient concentrations than surface waters. The upwelling phenomenon alters the physical properties of the surface waters, in addition to enhancing biological productivity.

RECEIVING WATER CHARACTERISTICS

The following discussion is focused on natural ocean temperatures along the southern California coast, in the Los Angeles-Long Beach region, and on other physical and chemical oceanographic characteristics that influence the marine biota.

Temperature

Natural sea water temperatures fluctuate throughout the year in response to seasonal and diurnal variations in currents, meteorological conditions such as wind, air temperature, relative humidity, and cloud cover, and other parameters including ocean waves and turbulence.

Natural surface water temperatures may be expected to vary 1 to 2°C in summer and 0.3 to 1°C in winter. Factors contributing to rapid diurnal warming of the sea surface are weak winds, clear skies, and warm air temperatures; whereas, factors limiting diurnal temperature ranges are overcast skies and moderate air temperatures, and mixing of the surface waters by winds and waves.

Natural surface water temperatures near the El Segundo Generating Station ranged between 17.8 to 19.8°C in March 1978 and 21.5 to 22.5°C in September 1978. During the thermal effects study of 1971-72, surface temperature patterns were similar to those reported in 1978 (LAS 1973).

When large differences between surface and bottom water temperatures exist, a thermocline may be formed. Such a phenomenon is characterized by a steep temperature gradient between adjacent water layers of different, but more uniform, temperatures. Natural thermoclines are formed when absorption of solar radiation at the sea surface develops a stable stratification, separating surface from subsurface layers. Artificial thermoclines may result when warm water from a thermal discharge overlies cooler receiving waters. Off southern California, a moderately sharp thermocline generally exists in summer months within the upper water column. In winter, weakly defined thermoclines may appear, although isothermal conditions are more prevalent.

Dissolved Oxygen

Dissolved oxygen in seawater is utilized by marine plants and animals in their normal metabolic processes and is replenished by gaseous exchange with the atmosphere and as a by-product of photosynthesis. Surface water concentrations offshore El Segundo between March 1978 and September 1978 ranged between 6.3 and 8.7 mg/l (IRC 1979). High values are often associated with increased photosynthetic activity, while low values may result from mixing of surface waters with oxygen depleted subsurface waters.

Hydrogen Ion Concentrations

The hydrogen ion concentration, or pH, in southern California surface waters varies narrowly around a mean of approximately 8.0, except for a slight decrease in pH with depth. The pH values recorded during two surveys conducted offshore of El Segundo in March and September 1978 ranged between 7.3 and 8.5 (IRC 1979).

Fish Populations

Fish populations in the receiving waters near the ESGS are representative of the large number of nearshore species common along the length of the Southern California Bight. Species observed during otterboard trawl collections for NPDES monitoring requirements (IRC 1979, 1981) included 10 of the 15 316(b) target species previously discussed. Most of these same species were present during trawl collections for a Thermal Effects Study at ESGS during 1971-72 (LAS 1973), including northern anchovy, queenfish, white croaker, white surfperch, and walleye surfperch.

The 316(b) target species recur frequently in offshore otterboard trawl samples, both near SCE generating stations and in other areas (Wingert 1981). Seven larval and six adult 316(b) target species were collected as far north as Pt. Conception during a 1980-81 study (MBC and CDF&G 1982). These observations point to a widely-distributed nearshore nekton community of a large number of target and other species, of which those observed in the area offshore ESGS are typical.

III. ENTRAINMENT

INTRODUCTION

Results of the physical and biological categorization of SCE intake characteristics were used to identify sites representative of the several intake types (velocity cap, canal, etc.) in the SCE system (Schlotterbeck et al. 1979). The study identified Ormond Beach Generating Station (OBGS) as representative of offshore velocity cap intakes. Entrainment data from OBGS (SCE 1982a) was used to estimate daily entrainment at ESGS Units 1 and 2 and Units 3 and 4. The intent of this section is to describe the methodology and results which provided input to the Impact Assessment Model as applied at ESGS. Included are a brief description of sampling methodology at representative sites, extrapolation of results to the ESGS, and discussion of the magnitude of entrainment of 316(b) target and other larval species.

METHODS AND MATERIALS

Mean daily entrainment at OBGS was determined from monthly samples collected from August 1979 through July 1980. During each monthly sampling survey, four replicate samples during each of six periods over a 24 hr day were pumped from within the offshore intake riser of the cooling water system. The six periods included two day, two night, and two crepuscular (sunset and sunrise) collections. A detailed description of methodology is presented in SCE (1982a). Mean daily larval entrainment densities for each month were calculated from larval abundance, day length, and station flow volume. Although entrainment mortality studies indicated survivorship of 10 to 70% for several target species, mortality of entrained larvae was assumed to be 100% (SCE 1982a), resulting in a conservative (higher than actual) estimate of entrainment effects. Estimates of entrainment at ESGS intakes were developed by applying a flow factor to OBGS entrainment levels based on differential flow volumes between the intake systems, expressed as:

$$\text{daily entrainment}_{(\text{ESGS 1\&2})} = \left[\frac{\text{flow rate}_{(\text{ESGS 1\&2})}}{\text{flow rate}_{(\text{OBGS})}}\right] \text{daily entrainment}_{(\text{OB})}$$

An identical approach was used to estimate entrainment at the Units 3 and 4 intake.

RESULTS AND DISCUSSION

Entrainment abundance was based on monthly estimates from OBGS 316(b) samples (Appendix III-1). Therefore, percent composition of the entrained larval community at the two ESGS intakes is identical, as would be expected from two intakes in close proximity (Schlotterbeck et al. 1979).

316(b) Target Species Abundance

The top-ranked species observed in entrainment collections were three 316(b) target species, which comprised 83.8% of the total estimated larval entrainment at ESGS (Table III-1). The most abundant species collected was larvae of northern anchovy, E. mordax, which comprised 41.8% of the total catch. Larvae of white croaker, G. lineatus, were the second most abundant species collected (33.8%); queenfish, S. politus, ranked third (8.2%).

Other 316(b) target species were insignificant in entrainment collections, totaling only 0.3% (Table III-1). Surfperches were not present at any time due to their live-bearing mode of birth. Spotfin croaker and bocaccio larvae were not collected. Larvae of kelp bass, barred sand bass, California butterfish, black croaker, yellowfin croaker, and sargo were present in low numbers (Table III-1). Target species comprised a total of 84.1% of all entrained larvae.

Abundance of Other Species

Species ranked 4-10 in entrainment collections at ESGS were not 316(b) target species, but comprised 14.2% of larval collections (Table III-1). Species listed in Table III-1 thereby comprised 98.3% of total larval entrainment. The remaining 1.7% was represented by 59 taxa not listed. Unidentified larvae and yolk sac life stages comprised 5.5 and 2.1%, respectively, of the entrainment catch. Other species taken included larvae of bay goby, Lepidogobius lepidus, cheekspot goby, Ilypnus gilberti, two taxa of unidentified gobies, and larvae of California halibut/fantail sole (the species are not distinguishable at the stage collected), Paralichthys californicus/Xystreurys liolepis.

Table III-1. Daily larval fish entrainment at El Segundo Generating Station Units 1 and 2 and Units 3 and 4 (number entrained x 10^5).

	Base Daily Entrainment (Ormond Beach)	Daily Larval Entrainment 1 & 2	Daily Larval Entrainment 3 & 4	Rank	% of Total
Volume Conversion Factor		0.3125	0.5603		
316(b) Target Species					
northern anchovy	22.07	6.90	12.37	1	41.8
white croaker	17.84	5.57	9.99	2	33.8
queenfish	4.33	1.35	2.43	3	8.2
Pacific butterfish	0.03	0.01	0.02	22	0.1
kelp bass	0.06	0.02	0.03	19	0.1
barred sand bass	0.05	0.01	0.03	20	0.1
sargo	<0.01	<0.01	<0.01	47	<0.1
spotfin croaker	--	--	--	--	--
bocaccio	--	--	--	--	--
black croaker	0.01	<0.01	<0.01	37	<0.1
yellowfin croaker	<0.01	<0.01	<0.01	42	<0.1
Total Target Species	44.39	13.85	24.83		84.1
Other Species					
Pisces larvae, unid.	2.89	0.90	1.62	4	5.5
bay goby	1.63	0.51	0.91	5	3.1
Pisces yolk sac larvae	1.12	0.35	0.63	6	2.1
cheekspot goby	1.03	0.32	0.58	7	2.0
goby type D	0.35	0.11	0.20	8	0.7
goby	0.27	0.08	0.15	9	0.5
California halibut/fantail sole	0.15	0.05	0.01	10	0.3
Other miscellaneous	0.92	0.29	0.52		1.7
TOTAL LARVAE	52.75	16.49	29.56		100.0

Patterns of Larval Entrainment

Larval entrainment peaked in the spring months, March through May, and again in the late summer/fall period from September through October (Appendix III-1). Minimum entrainment of larval fish occurred during the months of June and July. Magnitude of daily ichthyoplankton entrainment was directly related to the time of day. Entrainment densities were maximum between dusk and early morning hours, prior to sunrise, while minimum densities were observed near mid-day (SCE 1982a).

Peak entrainment periods for the larvae of northern anchovy were from February through May and again from August through October (Appendix III-1). Of the total number of northern anchovy larvae entrained, over 67% were in an early stage of development, ranging in size from 2 to 12 mm in length (SCE 1982a). The entrainment of white croaker larvae corresponded to the periods of reduced water temperature, with maximum entrainment densities observed during the period November through April (SCE 1982a). More than 91% of entrained white croaker larvae were observed in the 2 to 6 mm size classes. Larvae of queenfish were observed in the plankton from February through October, with peak densities occurring between April and September. Queenfish larvae in the 3 to 9 mm size groups comprised 96.7% of collected individuals (SCE 1982a). Entrainment of non-target species, including California halibut, bay goby, and cheekspot goby, were consistent with the primarily sand substrate in the area of the ESGS.

IV. IMPINGEMENT

INTRODUCTION

Adult fish losses at ESGS result from impingement at the two separate cooling water systems. Methods and materials and results of impingement collections are presented for each of the two intakes at ESGS. Daily impingement losses (as the sum of normal operation and heat treatment losses) are tabulated. Results are utilized in the Impact Assessment section to develop daily size class loss ratios for analysis of impact on the offshore populations.

METHODS AND MATERIALS

Impingement losses at SCE power station intakes occur during two different operational modes of the cooling system. During normal power generation, fish entrained with cooling waters are impinged on protective screens and removed from the intake screenwell. This is termed "normal operation" impingement. Periodically, most SCE stations reverse flow and elevate temperature in their cooling systems to control biofouling. Fish removed during these periods are grouped under "heat treatment" losses.

Normal Operation Fish Impingement Data Collection

Normal operation fish impingement data were collected on a regular basis from October 1978 through September 1980. Samples of all fish impinged during a 24-hr period were taken approximately once per week over the two-year period, with sampling increasing to approximately twice per week during a special 1-year study period from 1 August 1979 through 31 July 1980.

Traveling screens and trash baskets were initially cleared, and impinged organisms were allowed to accumulate for approximately 24 hours. Screens and baskets were then recleared and retained material and debris sorted into algal, invertebrate, and fish components. All normal operation loss data included the number of species, number of individuals per species, and weight per species.

Up to 200 individuals of each target species (Wintersteen and Dorn 1979) were measured to the nearest millimeter (standard length) and individuals (maximum of 50) were sexed. Non-target fish species that occurred in large numbers in impingement samples were also measured and sexed.

During the monitoring period, certain oceanographic, climatological and plant operational parameters were measured, including intake sea temperature, plant flow direction, turbidity (measured in nephalometric turbidity units), number of circulating pumps operating, wind, weather, and swell height.

Heat Treatment Data Collection

At approximately four- to six-week intervals, ESGS conducts heat treatments to control biofouling of the intake conduits. During a heat treatment, water in the intake screenwell was partially recirculated until temperatures were raised to approximately 105°F. At this temperature, all fish residing within the system were killed and subsequently impinged on the traveling screens.

Biologists attending heat treatment operations recorded the following parameters: (1) station and units (e.g. ESGS 1 and 2); (2) number of circulating pumps in operation; (3) intake seawater temperature; (4) maximum temperature in screenwell during heat treatment; (5) time and date; (6) weather; (7) wind speed; (8) swell height; (9) water turbidity; and (10) personnel present (contractor biologists, California Department of Fish and Game biologists and/or wardens, SCE biologists, etc.).

The responsible biologists ensured that traveling screens were operated immediately prior to commencement of the heat treatment and that all trash and previously impinged fish were removed. All impinged fish were collected during the temperature rise. The fish were then identified and separated by species to be counted and weighed. If the numbers of any species were so large as to make counting impractical an aliquot was taken of 200 randomly collected fish and the total numbers determined by the following formula:

$$\text{Estimated total number of Species A} = \frac{\text{Total weight of Species A}}{\text{Weight of 200 individuals of Species A}}(200)$$

The numbers and weight of each species were then recorded.

Select species were measured for length frequency distributions. Standard length was measured to the closest millimeter for up to 125 individuals (or all if less than 125 were present for any of the select species). If possible, sexes were determined in conjunction with length measurement for the first 50 individuals measured of each select species. Individuals measured and sexed were collected randomly throughout the heat treatment.

Estimation of Impingement Fish Losses

Normal operation fish losses (numbers and weight) were estimated by multiplying the mean daily impingement loss times the number of days that circulating water pumps were in operation during the period. The study period was stratified by month for purposes of analysis. Heat treatment fish loss, representing the actual count and weight, was added to the estimated normal operation fish loss to determine total fish loss on an annual basis.

The following formula was used to estimate impingement during a specified interval:

$$I_a = \left[\frac{D_o - D_h}{D_{n_a}}\right] N_{n_a} + N_{h_a}$$

where I_a = Estimated total impingement during interval of species "a"

D_h = Number of heat treatment days in a month
D_o = Number of operational days in month
N_{n_a} = Number of fish "a" taken in normal operation samples during month
D_{n_a} = Number of sample days during month
N_{h_a} = Number of fish "a" taken in heat treatments during interval

Total impingement for any given period was the sum of the normal operation collections within that period plus heat treatments.

The data are presented as daily fish impingement rates because that is the form used in the Impact Assessment Model. The daily rates can be used to determine impingement loss over any time period by multiplying by the appropriate number of days (i.e. daily x 365 = yearly).

RESULTS AND DISCUSSION

Units 1 and 2

Fish impingement at ESGS Units 1 and 2 was dominated by queenfish and walleye surfperch, comprising 50.1 and 22.4%, respectively, of total collections (Table IV-1). Queenfish were taken regularly during 22 of the 24 months of normal operation collections (Appendix IV-1), with peak abundances in impingement samples in December 1979 and February 1980. In both years the majority of adults were taken between December and April. Walleye surfperch were rarely taken during the first year of normal operation impingement collections. The majority of walleye were collected during the second year in December (Appendix IV-1).

Other species taken included white surfperch, white croaker, kelp bass, and shiner surfperch (Table IV-1), comprising 10.6, 4.0, 3.0, and 2.4%, respectively, of total impingement samples. The majority of white surfperch collected during normal operation were observed between August 1979 and March 1980 (Appendix IV-1). A similar pattern was noted for impinged white croaker. A major portion of the impingement totals for both kelp bass and shiner surfperch were taken during December 1979, when >75% of total normal operation impingement at Units 1 and 2 was recorded. The 316(b) target species comprised 96.0% of total impingement during the two-year study (Table IV-1). Non-target species comprised 4% of the impingement at Units 1 and 2.

Units 3 and 4

Queenfish comprised the major portion of impingement collections at ESGS Units 3 and 4 during the two-year study period. The species comprised 67.6% of total impingement (Table IV-2), and was regularly taken during most months of normal operation collections (Appendix IV-2). Adult queenfish were most abundant at Units 3 and 4 during December 1979 and March 1980.

The same group of species observed at Units 1 and 2 comprised much of the remaining impingement at Units 3 and 4. White croaker, shiner surfperch, white surfperch, walleye surfperch, and kelp bass comprised 8.6, 7.0, 5.3, 4.8, and 1.6%, respectively, of the total catch (Table IV-2). White croaker taken during normal operation were observed mainly in November 1978 and March 1980, with scattered observations during eight other months (Appendix IV-2). Most impinged individuals of the remaining four species were taken during December 1979 and March 1980. More than 62.5% of total normal operation impingement was observed during these two months. The 316(b) target species comprised 97.7% of total

Table IV-1. Daily fish impingement at El Segundo Generating Station Units 1 and 2 (number impinged).

Species	Daily Impingement: Normal Operation*	Heat Treatment**	Normal Operation + Heat Treatment	% of Total Impingement
316(b) Target Species				
northern anchovy	0.42	0.12	0.54	0.5
white croaker	2.36	2.25	4.61	4.0
queenfish	12.70	45.51	58.21	50.1
Pacific butterfish	0.37	0.42	0.79	0.7
kelp bass	0.38	3.12	3.50	3.0
barred sandbass	0.07	0.81	0.88	0.7
sargo	0.02	0.57	0.59	0.5
spotfin croaker	--	--	--	--
bocaccio	--	0.01	0.01	<0.1
black croaker	0.01	0.27	0.28	0.2
yellowfin croaker	--	--	--	--
shiner surfperch	1.02	1.82	2.84	2.4
black surfperch	0.10	0.93	1.03	0.9
walleye surfperch	8.66	17.37	26.03	22.4
white surfperch	0.78	11.56	12.34	10.6
Cumulative	26.89	84.76	111.65	96.0

* based on 146 samples
** based on 12 samples

Table IV-2. Daily fish impingement at El Segundo Generating Station Units 3 and 4 (number impinged).

Species	Daily Impingement: Normal Operation*	Heat Treatment**	Normal Operation + Heat Treatment	% of Total Impingement
316(b) Target Species				
northern anchovy	0.42	2.47	2.89	1.1
white croaker	1.85	19.96	21.81	8.5
queenfish	14.07	157.30	171.37	67.6
Pacific butterfish	0.21	0.44	0.65	0.3
kelp bass	0.05	4.03	4.08	1.6
barred sandbass	0.07	1.02	1.09	0.4
sargo	--	1.17	1.17	0.5
spotfin croaker	--	--	--	--
bocaccio	--	0.04	0.04	<0.1
black croaker	0.01	0.59	0.60	0.2
yellowfin croaker	0.01	0.02	0.03	<0.1
shiner surfperch	2.02	15.65	17.67	7.0
black surfperch	0.11	0.42	0.53	0.2
walleye surfperch	1.56	10.53	12.09	4.9
white surfperch	4.96	8.41	13.37	5.3
Cumulative	25.34	222.05	247.39	97.7

* based on 144 samples
** based on 13 samples

impingement during the two-year study (Table IV-2). Queenfish comprised slightly more than 50% of normal operation impingement, but almost 70% of the heat treatment collections, which accounted for >89% of total impingement (Table IV-2). Non-target species comprised 2.3% of the impingement at Units 3 and 4.

V. ASSESSMENT OF IMPACT

INTRODUCTION

The assessment of impact of the operation of the El Segundo Generating Station on fish resources in the nearshore zone of the Southern California Bight is a station-specific application of the Impact Assessment Model presented in complete form in Chapter 2 of the Technical Appendix (SCE 1982b). Components of the Impact Assessment Model include estimates of field population abundance, distribution, and age structure of selected 316(b) target species (Wintersteen and Dorn 1979). These estimates are compared to entrainment and impingement losses developed for each intake, resulting in a prediction of survival for individuals of each species over a specific time span.

The objectives of the Assessment of Impact section are to: 1) evaluate intake losses relative to the populations of adult and larval fishes; 2) estimate the probability of avoiding entrainment or impingement during a life span of five years, expressed as a percentage; 3) assign a level of impact to each intake for selected 316(b) target species; and 4) estimate the level of impact on other 316(b) target species that experience very low entrainment and impingement rates. The effect of alternate intake technologies on modifying this level of impact are discussed in Chapter VI.

A description of the Impact Assessment Model is presented in this chapter in abbreviated form. A complete derivation is included in the Technical Appendix (SCE 1982b). Input to the model for the purpose of defining the effect of operation of the ESGS includes population estimates of an individual species (SCE 1982b), and estimates of station entrainment and impingement losses discussed earlier (Chapters III and IV). The probability of a selected 316(b) species individual surviving entrainment and impingement during each of several age classes is developed, and a cumulative survival probability for the species presented. A level of impact on the source fish population based on the probability of survival of the operation of each intake is assigned. Levels of impact on the remaining 316(b) species are assigned based on similarities between species.

METHODS AND MATERIALS

The nearshore zone of the Southern California Bight from Point Conception to the Mexican border displays little coastal topography to significantly interrupt on-offshore mixing and few large natural embayments exist to serve as major nursery areas for larval fishes. The species of concern in these 316(b) studies are continuously distributed as larvae and adults throughout the Bight (SCE 1982b). Population estimates for selected 316(b) species were developed from SCE and other studies. Detailed methodology employed in formulating these estimates is presented in the Technical Appendix (SCE 1982b).

Estimates of entrainment and impingement losses at ESGS Units 1 and 2 and Units 3 and 4 were presented in Chapters III and IV, respectively. The analysis of the impact of these losses on nearshore fish populations was developed after the approach of MacCall et al. (1982). The model utilized in this study (SCE 1982b) calculates the magnitude of loss for all life stages, which are expressed here as size classes. The result is the probability (R_c) of a fish surviving entrainment and impingement mortality through a specific age (five years was chosen for this study). The statistic ($1-R_c$) indicates the percent probability of mortality due to station operation. The effect of losses in each size class is accumulated and passed on to later stages (a cumulative R_c value).

The probability of survival is estimated as a ratio of the size of the offshore population with and without the effect of the generating station intake, expressed as

$$R_c = e^{-\left[\sum_{i=1}^{i=c} (L_i/N_i)(t_i)\right]}$$

where R_c = relative strength through the c^{th} stage compared to an unaffected population (probability of survival),

L_i = daily losses of the i^{th} stage,

N_i = field population of the i^{th} stage,

t_i = duration of the i^{th} stage in days;

$$\text{age of the } c^{th} \text{ stage} = \sum_{i=1}^{i=c} t_i.$$

The derivation of the formula is presented in SCE (1982b). The ratio L_i/N_i represents daily intake mortality for a given stage (i). Multiplication by the estimated duration of the stage (t_i) gives a value which incorporates the duration of exposure to the loss rate.

Some life stages of the species of concern are undersampled, due to avoidance or sampling bias. Where necessary due to inadequate data, the L_i/N_i terms for these size groups (generally 20 to 90 mm) were estimated between the last larval stage with adequate data availability and the 90 mm stage, which is well-sampled in impingement collections. Estimates were based on the assumption of an exponential decline in loss rate from the larval to the adult stage (SCE 1982b).

Values for R_c were calculated individually for each size class and also accumulated as a species R_c. These values were calculated from data files established for each species based on: 1) entrainment or impingement levels from station collections; and 2) field estimates from the Los Angeles County Museum of Natural History program collections (Lavenberg and McGowen 1982). Egg data was used in estimating subsequent larval populations for northern anchovy. Since other eggs are difficult to identify, egg abundance was extrapolated from larval data for those species. In all cases the ratio of entrainment losses and field populations (L_i/N_i) in the egg stage was assumed to be identical to that in the 2 to 3 mm stage. This ratio was used to calculate the R_c value for the egg stage, and thus, no values for loss or field estimates of eggs appear in the impact tables. Significant figures associated with population or impact estimates were not standardized, in order to allow comparisons of relative behavior of variables within and between species.

Summary R_c data was separated into four categories according to general life history characteristics of all target species. The egg through 10 mm stages are generally incapable of avoiding entrainment or net collection. From 10 mm to 30 mm, sampling bias is introduced that results in reduced species specific entrainment levels. Larvae generally begin to acquire most juvenile and adult characteristics upon reaching approximately 30 mm length; however, surfperch young are juveniles at birth. A length of 90 mm was assumed to be the beginning of the adult stage.

The R_c value calculated for each species at the two ESGS intakes indicates the probability of individual survival over a five-year span. The probability of mortality ($1-R_c$) is assigned a level of impact on the nearshore population of each species. Three levels of impact are possible, including:

1) <u>None</u> - no entrainment and/or impingement losses at the intake;

2) <u>Insignificant</u> - observed losses will have no effect on the dynamics of the nearshore population. Long-term population observations would reveal no significant differences in abundance or distribution;

3) <u>Significant</u> - losses result in a discernable statistical effect on population abundance and/or distribution that could lead to economic and/or ecological impacts.

RESULTS AND DISCUSSION

Impact of Units 1 and 2

R_c values for individual size classes, a cumulative R_c, and a summary table of the contribution of each of the four major size groups to total station losses are presented for each of the six most abundant 316(b) target species: northern anchovy, white croaker, queenfish, kelp bass, shiner surfperch, and white surfperch. The R_c values for the species are discussed in relation to values of each size group and the overall effect of intake losses on the offshore population.

The Impact Assessment Model was applied to the six most abundant 316(b) target species. The evaluation of the remaining nine target species was based on: 1) the lack of significant entrainment and impingement numbers to represent concern for impact to a resource population; and 2) the absence of substantial life history information represented by measures of population size, distribution, reproductive strategy and fecundity to allow statistically valid loss/resource assessment.

Northern Anchovy

Entrainment of larval and juvenile individuals comprised the major losses of northern anchovy attributed to ESGS Units 1 and 2 (Table V-1). Larvae in size classes 10 to 30 mm comprised almost 85% of total losses, while juveniles in the 30 to 90 mm size range comprised slightly less than 11%. The latter values were interpolated between the extremes of collected individuals in the 29 to 30 and 90 to 100 mm ranges, as detailed in the Methods section above and SCE (1982b). Impingement of adult northern anchovy was sufficiently low that the cumulative R_c value was substantially unaffected by losses in the >90 mm size groups. The cumulative R_c value for northern anchovy at Units 1 and 2 was 99.8966, indicating that individuals are exposed to only a 0.1034% probability $(1-R_c)$ of entrainment or impingement mortality at Units 1 and 2 over a five-year period. This level of impact is not significant to the dynamics of the population.

White Croaker

The main losses for white croaker were associated with larval losses in size classes less than 30 mm (Table V-2). Losses in the egg to 10 mm and 10 to 30 mm categories were responsible for 45.8 and 50.4% of observed losses. The percent contribution of juveniles (30 to 90 mm) was greatly reduced compared to northern anchovy, while adult (>90 mm) contributions were slightly higher. Values between 26 and 90 mm were interpolated (SCE 1982b). The cumulative R_c value, 99.8159, indicated that individuals experienced only a 0.1841% probability of mortality from entrainment or impingement over a five-year period. This level of impact is not significant to the population.

Queenfish

Queenfish losses were predominantly attributable to losses in the adult size group. In contrast to the level of larval entrainment observed for northern anchovy and white croaker, entrainment losses in the egg to 10 mm size groups were less important (30.5%), while the influence of adult (>90 mm) impingement comprised 62.5% of total losses. Entrainment of larger larvae and impingement of juveniles (30 to 90 mm) was of minor importance (Table V-3).

Similar to white croaker, entrainment collections of larger queenfish larvae and juveniles were less than expected from an exponential decline in abundance with increasing size (SCE 1982b). Data between 20 and 90 mm were thereby interpolated as discussed previously (SCE 1982b). The cumulative R_c of 99.6454 for queenfish results in a 0.3546% probability that individuals will experience entrainment or impingement mortality at Units 1 and 2. This level of impact is not significant.

Kelp Bass

Kelp bass results are presented as a combination of kelp and barred sand bass. Losses of juveniles from interpolated data in the 30 to 90 mm size classes accounted for >68% of total losses, with 19.3% of the loss attributable to adult (>90 mm) impingement. Only 13.5% of total losses were observed in the larval size groups (Table V-4). The R_c statistic (99.8332) for kelp bass was higher than that observed for white croaker and queenfish, but lower than that calculated for northern anchovy. The R_c value indicated a 0.1668% probability that individuals would be subjected to entrainment or impingement mortality during a five-year life span. This level of impact is not significant.

Table V-1. Individual size class and summary size group R_c values developed for northern anchovy at El Segundo Generating Station Units 1 and 2.

SIZE CLASS (mm)	DAILY LOSS	FIELD ESTIMATE	DAYS/CLASS	Rc	CUMULATIVE Rc
ENTRAINMENT					
EGGS	*	*	1.596E+00	99.9994	99.9994
2 - 3	8.035E+04	2.240E+10	2.581E+00	99.9991	99.9985
3 - 4	2.113E+05	3.620E+10	2.581E+00	99.9985	99.9970
4 - 5	1.959E+04	1.183E+10	2.581E+00	99.9996	99.9966
5 - 6	1.248E+04	1.189E+10	1.865E+00	99.9998	99.9964
6 - 7	1.013E+04	1.117E+10	2.035E+00	99.9998	99.9962
7 - 8	8.460E+03	8.681E+09	2.193E+00	99.9998	99.9960
8 - 9	1.380E+04	8.108E+09	2.341E+00	99.9996	99.9956
9 - 10	2.507E+04	6.838E+09	2.480E+00	99.9991	99.9947
10 - 11	3.284E+04	6.214E+09	2.613E+00	99.9986	99.9933
11 - 12	3.774E+04	4.309E+09	2.740E+00	99.9976	99.9909
12 - 13	3.981E+04	2.931E+09	2.861E+00	99.9961	99.9870
13 - 14	3.080E+04	5.988E+09	2.978E+00	99.9985	99.9855
14 - 15	2.779E+04	1.888E+09	3.091E+00	99.9955	99.9809
15 - 16	2.475E+04	1.729E+09	3.200E+00	99.9954	99.9764
16 - 17	2.277E+04	2.844E+09	3.306E+00	99.9974	99.9737
17 - 18	2.328E+04	9.187E+08	3.409E+00	99.9914	99.9651
18 - 19	1.906E+04	1.080E+09	3.509E+00	99.9938	99.9589
19 - 20	1.707E+04	2.035E+09	3.607E+00	99.9970	99.9559
20 - 21	1.270E+04	6.523E+08	3.702E+00	99.9928	99.9486
21 - 22	1.091E+04	4.070E+08	3.795E+00	99.9898	99.9385
22 - 23	7.727E+03	1.047E+09	3.795E+00	99.9972	99.9357
23 - 24	5.256E+03	2.155E+08	3.795E+00	99.9908	99.9264
24 - 25	2.002E+03	1.180E+08	3.795E+00	99.9936	99.9200
25 - 26	1.641E+03	1.993E+08	3.795E+00	99.9969	99.9169
26 - 27	6.935E+02	7.067E+07	3.795E+00	99.9963	99.9132
27 - 28	3.750E+02	1.491E+08	3.795E+00	99.9991	99.9122
28 - 29	2.255E+02	3.533E+07	3.795E+00	99.9976	99.9098
29 - 30	1.403E+02	2.403E+07	3.795E+00	99.9978	99.9076
30 - 90	*	*	2.411E+02	99.9891	99.8966
IMPINGEMENT					
90 - 100	4.932E-02	3.263E+09	1.728E+02	100.0000	99.8966
100 - 110	2.466E-02	2.179E+09	2.015E+02	100.0000	99.8966

* denotes interpolated data values
E denotes scientific notation, e.g. : 1E06 = 1x10^6

CLASS	Rc	% CONTRIBUTION TO TOTAL LOSS
EGGS - 10mm	99.9947	5.1571
10mm - 30mm	99.9129	84.2615
30mm - 90mm	99.9891	10.5810
90mm +	100.0000	0.0005
TOTAL	99.8966	

Table V-2. Individual size class and summary size group R_c values developed for white croaker at El Segundo Generating Station Units 1 and 2.

SIZE CLASS (mm)	DAILY LOSS	FIELD ESTIMATE	DAYS/CLASS	Rc	CUMULATIVE Rc
ENTRAINMENT					
EGGS	*	*	1.373E+01	99.9807	99.9807
2 - 3	2.415E+05	1.719E+10	4.960E+00	99.9931	99.9738
3 - 4	1.127E+05	9.227E+09	4.960E+00	99.9939	99.9677
4 - 5	6.718E+04	5.588E+09	4.960E+00	99.9941	99.9617
5 - 6	8.045E+04	3.581E+09	4.960E+00	99.9889	99.9506
6 - 7	3.366E+04	2.288E+09	4.960E+00	99.9927	99.9433
7 - 8	1.496E+04	3.916E+08	4.960E+00	99.9811	99.9244
8 - 9	1.065E+04	1.435E+09	4.960E+00	99.9963	99.9207
9 - 10	4.934E+03	1.725E+09	4.960E+00	99.9986	99.9193
10 - 11	4.724E+03	2.576E+09	4.960E+00	99.9991	99.9184
11 - 12	2.679E+03	1.484E+09	4.960E+00	99.9991	99.9175
12 - 13	1.693E+03	1.075E+09	4.960E+00	99.9992	99.9167
13 - 14	8.899E+02	5.686E+08	4.960E+00	99.9992	99.9159
14 - 15	6.309E+02	4.187E+08	4.960E+00	99.9993	99.9152
15 - 16	4.614E+02	2.443E+08	4.960E+00	99.9991	99.9142
16 - 17	2.377E+02	1.288E+08	4.960E+00	99.9991	99.9133
17 - 18	4.081E+01	1.614E+07	4.960E+00	99.9988	99.9121
18 - 19	5.998E+01	2.968E+07	4.960E+00	99.9990	99.9111
19 - 20	3.753E+01	8.748E+06	4.960E+00	99.9979	99.9089
20 - 21	7.618E+01*	1.137E+07	4.960E+00	99.9967	99.9056
21 - 22	1.148E+02	1.400E+07	4.960E+00	99.9959	99.9016
22 - 23	7.178E+01*	1.309E+07	4.960E+00	99.9973	99.8988
23 - 24	7.178E+01*	1.309E+07	4.960E+00	99.9973	99.8961
24 - 25	7.178E+01*	1.309E+07	4.960E+00	99.9973	99.8934
25 - 26	2.871E+01	1.218E+07	4.960E+00	99.9988	99.8922
26 - 90	*	*	1.350E+02	99.9949	99.8871
IMPINGEMENT					
90 - 100	1.534E-01	3.161E+07	1.102E+02	100.0000	99.8871
100 - 110	2.110E-01	3.168E+07	1.265E+02	99.9999	99.8870
110 - 120	2.986E-01	3.077E+07	1.434E+02	99.9999	99.8868
120 - 130	6.247E-01	2.899E+07	1.609E+02	99.9997	99.8865
130 - 140	9.123E-01	2.652E+07	1.790E+02	99.9994	99.8859
140 - 150	1.458E+00	2.358E+07	1.975E+02	99.9988	99.8847
150 - 160	1.096E-01	2.039E+07	2.166E+02	99.9999	99.8845
160 - 170	6.027E-01	1.714E+07	2.361E+02	99.9992	99.8837
170 - 180	6.877E-01	1.402E+07	2.561E+02	99.9988	99.8825

* denotes interpolated data values
E denotes scientific notation, e.g. : 1E06 = 1x10^6

CLASS	Rc	% CONTRIBUTION TO TOTAL LOSS
EGGS - 10mm	99.9193	68.6618
10mm - 30mm	99.9722	23.6527
30mm - 90mm	99.9956	3.7214
90mm +	99.9953	3.9642
TOTAL	99.8825	

Table V-3. Individual size class and summary size group R_c values developed for queenfish at El Segundo Generating Station Units 1 and 2.

SIZE CLASS (mm)	DAILY LOSS	FIELD ESTIMATE	DAYS/CLASS	Rc	CUMULATIVE Rc
ENTRAINMENT					
EGGS	*	*	6.940E+00	99.9993	99.9993
2 - 3	2.438E+03	2.571E+09	3.900E+00	99.9996	99.9990
3 - 4	4.991E+03	8.570E+08	3.900E+00	99.9977	99.9967
4 - 5	2.666E+04	9.624E+08	3.900E+00	99.9892	99.9859
5 - 6	7.556E+04	6.653E+08	3.900E+00	99.9557	99.9416
6 - 7	2.818E+04	3.874E+08	3.900E+00	99.9716	99.9133
7 - 8	2.292E+03	4.612E+07	3.900E+00	99.9806	99.8939
8 - 9	8.859E+01	2.801E+07	3.900E+00	99.9988	99.8927
9 - 10	5.266E+01	1.880E+07	3.900E+00	99.9989	99.8916
10 - 11	8.121E+01	2.260E+07	3.900E+00	99.9986	99.8902
11 - 12	1.116E+02	1.281E+07	3.900E+00	99.9966	99.8868
12 - 13	2.707E+01	1.202E+07	3.900E+00	99.9991	99.8859
13 - 14	2.707E+01*	4.041E+06	3.900E+00	99.9974	99.8833
14 - 15	2.707E+01	5.436E+06	3.900E+00	99.9981	99.8814
15 - 16	2.707E+01*	4.918E+06	3.900E+00	99.9979	99.8792
16 - 17	2.707E+01*	5.078E+06	3.900E+00	99.9979	99.8771
17 - 18	2.707E+01	5.948E+06	3.900E+00	99.9982	99.8754
18 - 19	2.707E+01	1.670E+07	3.900E+00	99.9994	99.8748
19 - 20	2.871E+01	1.357E+07	3.900E+00	99.9992	99.8739
20 - 90	*	*	1.058E+02	99.9929	99.8669
IMPINGEMENT					
90 - 100	5.370E-01	5.168E+06	7.547E+01	99.9992	99.8661
100 - 110	3.781E+00	5.523E+06	9.478E+01	99.9935	99.8596
110 - 120	1.041E+01	5.562E+06	1.166E+02	99.9782	99.8378
120 - 130	8.014E+00	5.270E+06	1.409E+02	99.9786	99.8164
130 - 140	7.866E+00	4.688E+06	1.679E+02	99.9718	99.7883
140 - 150	6.542E+00	3.904E+06	1.976E+02	99.9669	99.7553
150 - 160	5.877E+00	3.034E+06	2.300E+02	99.9555	99.7108
160 - 170	1.573E+00	2.191E+06	2.652E+02	99.9810	99.6919
170 - 180	7.397E-01	1.464E+06	3.032E+02	99.9847	99.6766
180 - 190	8.192E-01	9.021E+05	3.441E+02	99.9688	99.6454

* denotes interpolated data values
E denotes scientific notation, e.g. : 1E06 = 1x10^6

CLASS	Rc	% CONTRIBUTION TO TOTAL LOSS
EGGS - 10mm	99.8916	30.5399
10mm - 30mm	99.9797	5.7130
30mm - 90mm	99.9956	1.2558
90mm +	99.7783	62.4914
TOTAL	99.6454	

Table V-4. Individual size class and summary size group R_c values developed for kelp bass (presented as a combination of kelp bass and barred sand bass) at El Segundo Generating Station Units 1 and 2.

SIZE CLASS (mm)	DAILY LOSS	FIELD ESTIMATE	DAYS/CLASS	Rc	CUMULATIVE Rc
ENTRAINMENT					
EGGS	*	*	6.269E+00	99.9984	99.9984
2 - 3	1.893E+03	7.391E+08	5.999E+00	99.9985	99.9969
3 - 4	9.335E+01	4.628E+08	5.999E+00	99.9999	99.9967
4 - 5	7.362E+01*	2.284E+08	5.999E+00	99.9998	99.9966
5 - 6	7.362E+01*	4.031E+07	5.504E+00	99.9990	99.9956
6 - 7	7.362E+01*	1.044E+07	1.699E+00	99.9988	99.9943
7 - 8	7.362E+01*	1.413E+07	1.699E+00	99.9991	99.9935
8 - 9	7.362E+01*	4.307E+06	1.699E+00	99.9971	99.9906
9 - 10	5.389E+01	2.301E+06	1.699E+00	99.9960	99.9866
10 - 90	*	*	4.544E+02	99.8772	99.8638
IMPINGEMENT					
90 - 100	8.219E-03	2.023E+06	7.178E+01	100.0000	99.8637
100 - 110	1.233E-02*	1.967E+06	7.393E+01	100.0000	99.8637
110 - 120	1.644E-02	1.905E+06	7.594E+01	99.9999	99.8636
120 - 130	4.384E-02	1.838E+06	7.784E+01	99.9998	99.8634
130 - 140	8.219E-02	1.767E+06	7.962E+01	99.9996	99.8631
140 - 150	4.384E-02	1.694E+06	8.132E+01	99.9998	99.8629
150 - 160	6.575E-02	1.619E+06	8.294E+01	99.9997	99.8625
160 - 170	9.863E-02	1.544E+06	8.448E+01	99.9995	99.8620
170 - 180	2.329E-01	1.469E+06	8.596E+01	99.9986	99.8606
180 - 190	2.795E-01	1.395E+06	8.738E+01	99.9983	99.8589
190 - 200	3.589E-01	1.321E+06	8.875E+01	99.9976	99.8565
200 - 210	3.753E-01	1.250E+06	9.007E+01	99.9973	99.8538
210 - 220	4.356E-01	1.180E+06	9.134E+01	99.9966	99.8504
220 - 230	4.493E-01	1.112E+06	9.258E+01	99.9963	99.8467
230 - 240	3.342E-01	1.047E+06	9.377E+01	99.9970	99.8437
240 - 250	2.795E-01	9.840E+05	9.493E+01	99.9973	99.8410
250 - 260	1.096E-01	9.235E+05	9.606E+01	99.9989	99.8398
260 - 270	8.219E-02	8.656E+05	9.715E+01	99.9991	99.8389
270 - 280	6.027E-02	8.102E+05	9.822E+01	99.9993	99.8382
280 - 290	3.836E-02	7.575E+05	9.926E+01	99.9995	99.8377
290 - 300	1.918E-02	7.074E+05	1.003E+02	99.9997	99.8374
300 - 310	3.014E-02	6.598E+05	1.013E+02	99.9995	99.8370
310 - 320	1.370E-02	6.148E+05	1.022E+02	99.9998	99.8367
320 - 330	1.644E-02	5.723E+05	1.032E+02	99.9997	99.8364
330 - 340	3.836E-02*	5.321E+05	1.041E+02	99.9993	99.8357
340 - 350	3.836E-02*	4.943E+05	1.050E+02	99.9992	99.8349
350 - 400	6.027E-02	1.980E+06	5.381E+02	99.9984	99.8332

* denotes interpolated data values
E denotes scientific notation, e.g. : 1E06 = 1x10^6

CLASS	Rc	% CONTRIBUTION TO TOTAL LOSS
EGGS - 10mm	99.9866	8.0455
10mm - 30mm	99.9908	5.5062
30mm - 90mm	99.8863	68.1323
90mm +	99.9694	18.3160
TOTAL	99.8332	

Shiner Surfperch

Shiner surfperch are viviparous, resulting in the release of juveniles of approximately 35 mm length at parturition. Impingement of juveniles, normally calculated from entrainment and impingement at size classes observed in loss samples (SCE 1982b), was estimated from impingement collections of gravid white surfperch females. As a result, no losses of larvae <30 mm is possible, so the R_c values for these size groups is 100. The majority of shiner surfperch loss occurs in the adult (>90 mm) groups (81.8%), with some contribution from juvenile (30 to 90 mm) losses (18.2%; Table V-5). Total losses in both categories are low, resulting in an R_c value of 99.8460. Individuals are thereby exposed to a 0.1540% probability of mortality from impingement (no entrainment probability) during a five-year period. This level of impact is insignificant.

White Surfperch

White surfperch are also viviparous, resulting in no losses due to larval entrainment. Additionally, parturition takes place at approximately 54 mm, resulting in a lower percent contribution of juveniles to total station losses (1%; Table V-6). The vast majority of loss (99%) is due to adult impingement. The species R_c value is 99.7689, resulting in a 0.2311% probability of mortality due to impingement over a five-year period, a level of impact that is not significant.

Table V-5. Individual size class and summary size group R_c values developed for shiner surfperch at El Segundo Generating Station Units 1 and 2.

SIZE CLASS (mm)	DAILY LOSS	FIELD ESTIMATE	DAYS/CLASS	Rc	CUMULATIVE Rc
ENTRAINMENT					
IMPINGEMENT					
35 - 40	1.442E-01*	3.850E+05	6.873E+01	99.9974	99.9974
40 - 50	1.512E-01*	4.088E+05	1.375E+02	99.9949	99.9923
50 - 60	6.361E-02*	1.720E+05	1.375E+02	99.9949	99.9873
60 - 70	2.676E-02*	7.234E+04	1.375E+02	99.9949	99.9822
70 - 80	1.126E-02*	3.043E+04	1.375E+02	99.9949	99.9771
80 - 90	4.735E-03*	1.280E+04	1.375E+02	99.9949	99.9720
90 - 100	3.726E-01	2.754E+05	1.375E+02	99.9814	99.9534
100 - 110	2.685E-01	5.689E+05	4.271E+02	99.9799	99.9333
110 - 120	3.479E-01	2.648E+05	3.607E+02	99.9526	99.8859
120 - 130	1.644E-01	1.719E+05	4.181E+02	99.9600	99.8460

* denotes interpolated data values
E denotes scientific notation, e.g. : 1E06 = 1x10^6

CLASS	Rc	% CONTRIBUTION TO TOTAL LOSS
EGGS - 10mm	100.0000	0.0000
10mm - 30mm	100.0000	0.0000
30mm - 90mm	99.9720	18.1642
90mm +	99.8740	81.8359
TOTAL	99.8460	

Table V-6. **Individual size class and summary size group R_c values developed for white surfperch at El Segundo Generating Station Units 1 and 2.**

SIZE CLASS (mm)	DAILY LOSS	FIELD ESTIMATE	DAYS/CLASS	Rc	CUMULATIVE Rc
ENTRAINMENT					
IMPINGEMENT					
54 - 60	3.324E-02*	3.483E+05	3.672E+01	99.9997	99.9997
60 - 70	4.827E-02*	4.421E+05	6.120E+01	99.9993	99.9990
70 - 80	3.283E-02*	3.007E+05	6.120E+01	99.9993	99.9983
80 - 90	2.233E-02*	2.045E+05	6.120E+01	99.9993	99.9977
90 - 100	6.575E-02	4.902E+05	6.120E+01	99.9992	99.9968
100 - 110	6.575E-02	7.992E+05	1.101E+02	99.9991	99.9959
110 - 120	1.753E-01	7.167E+05	1.121E+02	99.9973	99.9932
120 - 130	3.918E-01	7.317E+05	1.317E+02	99.9930	99.9861
130 - 140	4.411E-01	7.209E+05	1.527E+02	99.9907	99.9768
140 - 150	2.575E-01	6.854E+05	1.753E+02	99.9934	99.9702
150 - 160	4.712E-01	6.287E+05	1.993E+02	99.9851	99.9553
160 - 170	1.038E+00	5.560E+05	2.249E+02	99.9580	99.9133
170 - 180	1.019E+00	4.738E+05	2.519E+02	99.9459	99.8592
180 - 190	1.255E+00	3.887E+05	2.803E+02	99.9096	99.7609

* denotes interpolated data values
E denotes scientific notation, e.g. : 1E06 = 1x10^6

CLASS	Rc	% CONTRIBUTION TO TOTAL LOSS
EGGS - 10mm	100.0000	0.0000
10mm - 30mm	100.0000	0.0000
30mm - 90mm	99.9977	1.0177
90mm +	99.7712	98.9823
TOTAL	99.7689	

Other 316(b) Target Species

R_c values were not developed for the remaining 316(b) target species due to low levels of entrainment and/or impingement. The six species discussed above represented more than 99% of station target species entrainment and more than 71% of target species impingement. Analysis of the remaining species was based on a comparison of entrainment and impingement levels compared to the six species for which predictions of survival were developed.

Pacific Butterfish. Entrainment of Pacific butterfish at Units 1 and 2 represented 0.1% of total station entrainment (Chapter III, Table III-1). The species comprised only 0.7% of total impingement collections (Chapter IV, Table IV-1). Based on the R_c values developed for the 316(b) species entrained or impinged in much greater numbers, the impact of these losses on populations of butterfish is insignificant.

Sargo. The species represented <0.1% of total entrainment losses (Chapter III, Table III-1) and 0.5% of total impingement losses (Chapter IV, Table IV-1). On the basis of R_c values for species entrained or impinged in much greater numbers, this level of impact is not significant.

Spotfin Croaker. No individuals of this species were entrained or impinged during the 316(b) study.

Bocaccio. No larvae of this species were observed in entrainment collections at ESGS Units 1 and 2. A mean annual total of four individuals were impinged during the 316(b) study period (Chapter IV, Table IV-1), indicating no impact on the nearshore population.

Black Croaker. Larvae of black croaker represented only 0.1% of entrainment collections at Units 1 and 2 (Chapter III, Table III-1). The species comprised only 0.2% of total annual impingement (Chapter IV, Table IV-1). While no R_c value was developed, this loss level indicates that no adverse effect on the population results from operation of Units 1 and 2.

Yellowfin Croaker. No adult yellowfin croaker were observed in impingement collections at Units 1 and 2, and entrainment collections of the species comprised <0.1% of the total catch (Chapter III, Table III-1), resulting in no impact to the population.

Black Surfperch. No larvae of this species were entrained due to their life history at parturition. The species comprised only 0.9% of total station impingement (Chapter IV, Table IV-1), a level of impact considered insignificant to the population.

Walleye Surfperch. No larvae were entrained due to the ontogenetic mode of development of the species. Impingement levels comprised 22.4% of total collections (Chapter IV, Table IV-1). Walleye surfperch are similar to shiner surfperch in population abundance (SCE 1982b). Based on the R_c developed for shiner surfperch, the level of impact observed on walleye surfperch population is insignificant.

Table V-7. Summary of station impact at El Segundo Generating Station Units 1 and 2.

Species	R_c	% Probability of Mortality Due to Station Operation $(1-R_c)$	Impact
northern anchovy	99.8966	0.1034	insignificant
white croaker	99.8159	0.1841	insignificant
queenfish	99.6454	0.3546	insignificant
kelp bass*	99.8332	0.1668	insignificant
shiner surfperch	99.8460	0.1540	insignificant
white surfperch	99.7689	0.2311	insignificant
Pacific butterfish	**	**	insignificant
sargo	**	**	insignificant
spotfin croaker	**	**	none
bocaccio	**	**	none
black croaker	**	**	insignificant
yellowfin croaker	**	**	none
black surfperch	**	**	insignificant
walleye surfperch	**	**	insignificant

* includes barred sandbass

** R_c values not developed due to low level of entrainment and/or impingement (see text)

A summary of R_c values, percent probability of mortality due to station operation $(1-R_c)$, and level of impact of ESGS Units 1 and 2 is presented in Table V-7.

Impact of Units 3 and 4

Northern Anchovy

The contributions of the four major size groups of entrained and impinged northern anchovy at ESGS Units 3 and 4 was, as expected, similar to that observed for Units 1 and 2 (Tables V-1 and V-8). Large larvae in the 10 to 30 mm range comprised >84% of total losses, while juveniles in the 30 to 90 mm groups comprised less than 11%. Percent losses in the juvenile and adult range at Units 3 and 4 were slightly higher than those observed at Units 1 and 2 due to the higher rates of daily impingement at the latter intake (Table IV-2), but the difference in R_c values was larger. The lower cumulative R_c value for northern anchovy at Units 3 and 4 (99.8144) was due to the increased cooling water flow volume at that intake. This lower value results in only a 0.1856% probability that individuals will be subjected to entrainment or impingement mortality during a five-year period. This level of impact is not significant.

Table V-8. Individual size class and summary size group R_c values developed for northern anchovy at El Segundo Generating Station Units 3 and 4.

SIZE CLASS (mm)	DAILY LOSS	FIELD ESTIMATE	DAYS/CLASS	Rc	CUMULATIVE Rc
ENTRAINMENT					
EGGS	*	*	1.596E+00	99.9990	99.9990
2 - 3	1.441E+05	2.240E+10	2.581E+00	99.9984	99.9973
3 - 4	3.788E+05	3.620E+10	2.581E+00	99.9973	99.9946
4 - 5	3.512E+04	1.183E+10	2.581E+00	99.9992	99.9939
5 - 6	2.238E+04	1.189E+10	1.865E+00	99.9997	99.9935
6 - 7	1.816E+04	1.117E+10	2.035E+00	99.9997	99.9932
7 - 8	1.517E+04	8.681E+09	2.193E+00	99.9996	99.9928
8 - 9	2.474E+04	8.108E+09	2.341E+00	99.9993	99.9921
9 - 10	4.495E+04	6.838E+09	2.480E+00	99.9984	99.9904
10 - 11	5.888E+04	6.214E+09	2.613E+00	99.9975	99.9880
11 - 12	6.767E+04	4.309E+09	2.740E+00	99.9957	99.9837
12 - 13	7.139E+04	2.931E+09	2.861E+00	99.9930	99.9767
13 - 14	5.522E+04	5.988E+09	2.978E+00	99.9973	99.9739
14 - 15	4.983E+04	1.888E+09	3.091E+00	99.9918	99.9658
15 - 16	4.437E+04	1.729E+09	3.200E+00	99.9918	99.9576
16 - 17	4.082E+04	2.844E+09	3.306E+00	99.9953	99.9529
17 - 18	4.174E+04	9.187E+08	3.409E+00	99.9845	99.9374
18 - 19	3.418E+04	1.080E+09	3.509E+00	99.9889	99.9263
19 - 20	3.061E+04	2.035E+09	3.607E+00	99.9946	99.9208
20 - 21	2.277E+04	6.523E+08	3.702E+00	99.9871	99.9079
21 - 22	1.956E+04	4.070E+08	3.795E+00	99.9818	99.8897
22 - 23	1.385E+04	1.047E+09	3.795E+00	99.9950	99.8847
23 - 24	9.423E+03	2.155E+08	3.795E+00	99.9834	99.8681
24 - 25	3.590E+03	1.180E+08	3.795E+00	99.9885	99.8566
25 - 26	2.943E+03	1.993E+08	3.795E+00	99.9944	99.8510
26 - 27	1.243E+03	7.067E+07	3.795E+00	99.9933	99.8443
27 - 28	6.723E+02	1.491E+08	3.795E+00	99.9983	99.8426
28 - 29	4.044E+02	3.533E+07	3.795E+00	99.9957	99.8383
29 - 30	2.515E+02	2.403E+07	3.795E+00	99.9960	99.8343
30 - 90	*	*	2.411E+02	99.9800	99.8144
IMPINGEMENT					
90 - 100	1.123E-01	3.263E+09	1.728E+02	100.0000	99.8144
100 - 110	1.014E-01	2.179E+09	2.015E+02	100.0000	99.8144
110 - 120	1.178E-01	1.353E+09	2.416E+02	100.0000	99.8144
120 - 130	9.041E-02	7.571E+08	3.018E+02	100.0000	99.8144
130 - 140	1.096E-02	3.603E+08	4.023E+02	100.0000	99.8144

* denotes interpolated data values
E denotes scientific notation, e.g. : 1E06 = 1x10^6

CLASS	Rc	% CONTRIBUTION TO TOTAL LOSS
EGGS - 10mm	99.9904	5.1466
10mm - 30mm	99.8439	84.0893
30mm - 90mm	99.9800	10.7595
90mm +	100.0000	0.0046
TOTAL	99.8144	

White Croaker

Differences in cooling water flow volume between Units 1 and 2 and Units 3 and 4 were also reflected in comparative R_c values at the two intakes. Percent contribution to total losses of white croaker for the two intakes were almost identical for all four major size groups (Tables V-2 and V-9), but the cumulative R_c at Units 3 and 4 (99.6742) was lower than that at Units 1 and 2 (99.8159). Even this lower value at Units 3 and 4 resulted in only a 0.3258% probability that white croaker individuals would experience impingement or entrainment mortality during a five-year life span. This level of impact is not significant.

Queenfish

As was observed at Units 1 and 2, impingement of adults and entrainment of small larvae represented the major contribution to the losses at Units 3 and 4 (Table V-10), comprising 61.4 and 30.4%, respectively. Entrainment of larger larvae and impingement of juveniles comprised only 8.1% of total losses. The cumulative R_c value for queenfish at Units 3 and 4 was 99.3628, indicating a 0.6372% probability of exposure to entrainment or impingement mortality during a five-year span. This level of impact is not significant.

Kelp Bass

Entrainment of kelp bass larvae (a combination of kelp and barred sand bass for the purposes of this study) was restricted to size groups of <10 mm (Table V-11). As a result, values for both larger larval entrainment and juvenile impingement were interpolated (SCE 1982b). The length of the period of interpolation (10 to 90 mm, 454 days), combined with low levels of adult impingement, resulted in the impingement of juvenile fishes contributing the majority of station losses for this species. Losses for each of the other three size groups were less than 0.04%, but the R_c value for juveniles (99.7958) resulted in a cumulative R_c value of 99.7245, indicating a 0.2755% probability of mortality due to entrainment or impingement during a five-year period. This level of impact is not significant.

Shiner Surfperch

Losses of shiner surfperch at Units 3 and 4 were restricted to the impingement of juveniles and adults due to the viviparous life history of newborn individuals. Juvenile impingement comprised 22.8% and adult impingement 77.2% of losses (Table V-12), resulting in a cumulative R_c value of 99.2376. This indicated a 0.7624% probability that individuals will experience impingement mortality during a five-year life span, a level considered insignificant.

White Surfperch

White surfperch experienced no entrainment losses at Units 3 and 4, due to their viviparous mode of birthing. The large size of newborn juveniles also reduced the exposure time of impingement prior to 90 mm. As a result, 99.4% of white surfperch losses at Units 3 and 4 occurred in the adult size groups (>90 mm; Table V-13). The cumulative R_c value, 99.5498, indicated a 0.4502% probability of impingement mortality due to station operation over a five-year period, a level considered insignificant.

Other 316(b) Target Species

As was discussed for Units 1 and 2, R_c values were not developed for the remaining 316(b) species at Units 3 and 4 due to the low levels of entrainment and impingement. The six principal target species discussed above comprised more than 99% of target species entrainment and more than 91% of target species impingement.

Table V-9. Individual size class and summary size group R_c values developed for white croaker at El Segundo Generating Station Units 3 and 4.

SIZE CLASS (mm)	DAILY LOSS	FIELD ESTIMATE	DAYS/CLASS	Rc	CUMULATIVE Rc
ENTRAINMENT					
EGGS	*	*	1.373E+01	99.9654	99.9654
2 - 3	4.330E+05	1.719E+10	4.960E+00	99.9875	99.9530
3 - 4	2.021E+05	9.227E+09	4.960E+00	99.9891	99.9421
4 - 5	1.204E+05	5.588E+09	4.960E+00	99.9893	99.9314
5 - 6	1.442E+05	3.581E+09	4.960E+00	99.9800	99.9114
6 - 7	6.035E+04	2.288E+09	4.960E+00	99.9869	99.8984
7 - 8	2.683E+04	3.916E+08	4.960E+00	99.9660	99.8644
8 - 9	1.910E+04	1.435E+09	4.960E+00	99.9934	99.8578
9 - 10	8.846E+03	1.725E+09	4.960E+00	99.9975	99.8553
10 - 11	8.469E+03	2.576E+09	4.960E+00	99.9984	99.8537
11 - 12	4.803E+03	1.484E+09	4.960E+00	99.9984	99.8521
12 - 13	3.035E+03	1.075E+09	4.960E+00	99.9986	99.8507
13 - 14	1.596E+03	5.686E+08	4.960E+00	99.9986	99.8493
14 - 15	1.131E+03	4.187E+08	4.960E+00	99.9987	99.8480
15 - 16	8.273E+02	2.443E+08	4.960E+00	99.9983	99.8463
16 - 17	4.261E+02	1.288E+08	4.960E+00	99.9984	99.8446
17 - 18	7.317E+01	1.614E+07	4.960E+00	99.9977	99.8424
18 - 19	1.075E+02	2.968E+07	4.960E+00	99.9982	99.8406
19 - 20	6.729E+01	8.748E+06	4.960E+00	99.9962	99.8368
20 - 21	1.366E+02*	1.137E+07	4.960E+00	99.9941	99.8308
21 - 22	2.059E+02	1.400E+07	4.960E+00	99.9927	99.8236
22 - 23	1.287E+02*	1.309E+07	4.960E+00	99.9951	99.8187
23 - 24	1.287E+02*	1.309E+07	4.960E+00	99.9951	99.8138
24 - 25	1.287E+02*	1.309E+07	4.960E+00	99.9951	99.8089
25 - 26	5.148E+01	1.218E+07	4.960E+00	99.9979	99.8069
26 - 90	*	*	1.350E+02	99.9903	99.7972
IMPINGEMENT					
90 - 100	3.863E-01	3.161E+07	1.102E+02	99.9999	99.7970
100 - 110	4.247E-01	3.168E+07	1.265E+02	99.9998	99.7968
110 - 120	1.918E-01	3.077E+07	1.434E+02	99.9999	99.7968
120 - 130	3.397E-01	2.899E+07	1.609E+02	99.9998	99.7966
130 - 140	4.822E-01	2.652E+07	1.790E+02	99.9997	99.7962
140 - 150	6.767E-01	2.358E+07	1.975E+02	99.9994	99.7957
150 - 160	6.767E-01	2.039E+07	2.166E+02	99.9993	99.7950
160 - 170	5.671E-01	1.714E+07	2.361E+02	99.9992	99.7942
170 - 180	5.671E-01	1.402E+07	2.561E+02	99.9990	99.7932

* denotes interpolated data values
E denotes scientific notation, e.g. : 1E06 = 1x10^6

CLASS	Rc	% CONTRIBUTION TO TOTAL LOSS
EGGS - 10mm	99.8553	69.9296
10mm - 30mm	99.9501	24.1268
30mm - 90mm	99.9917	4.0069
90mm +	99.9960	1.9367
TOTAL	99.7932	

Table V-10. Individual size class and summary size group R_c values developed for queenfish at El Segundo Station Units 3 and 4.

SIZE CLASS (mm)	DAILY LOSS	FIELD ESTIMATE	DAYS/CLASS	Rc	CUMULATIVE Rc
ENTRAINMENT					
EGGS	*	*	6.940E+00	99.9988	99.9988
2 - 3	4.371E+03	2.571E+09	3.900E+00	99.9993	99.9982
3 - 4	8.948E+03	8.570E+08	3.900E+00	99.9959	99.9941
4 - 5	4.780E+04	9.624E+08	3.900E+00	99.9807	99.9747
5 - 6	1.355E+05	6.653E+08	3.900E+00	99.9206	99.8954
6 - 7	5.052E+04	3.874E+08	3.900E+00	99.9492	99.8446
7 - 8	4.110E+03	4.612E+07	3.900E+00	99.9652	99.8099
8 - 9	1.588E+02	2.801E+07	3.900E+00	99.9978	99.8077
9 - 10	9.442E+01	1.880E+07	3.900E+00	99.9981	99.8057
10 - 11	1.456E+02	2.260E+07	3.900E+00	99.9975	99.8032
11 - 12	2.000E+02	1.281E+07	3.900E+00	99.9939	99.7971
12 - 13	4.853E+01	1.202E+07	3.900E+00	99.9984	99.7955
13 - 14	4.853E+01*	4.041E+06	3.900E+00	99.9953	99.7909
14 - 15	4.853E+01	5.436E+06	3.900E+00	99.9965	99.7874
15 - 16	4.853E+01*	4.918E+06	3.900E+00	99.9962	99.7836
16 - 17	4.853E+01*	5.078E+06	3.900E+00	99.9963	99.7798
17 - 18	4.853E+01	5.948E+06	3.900E+00	99.9968	99.7767
18 - 19	4.853E+01	1.670E+07	3.900E+00	99.9989	99.7755
19 - 20	5.148E+01	1.357E+07	3.900E+00	99.9985	99.7741
20 - 90	*	*	1.058E+02	99.9798	99.7539
IMPINGEMENT					
90 - 100	4.074E+00	5.168E+06	7.547E+01	99.9941	99.7479
100 - 110	6.375E+00	5.523E+06	9.478E+01	99.9891	99.7370
110 - 120	1.993E+01	5.562E+06	1.166E+02	99.9582	99.6954
120 - 130	1.395E+01	5.270E+06	1.409E+02	99.9627	99.6582
130 - 140	1.378E+01	4.688E+06	1.679E+02	99.9507	99.6090
140 - 150	1.261E+01	3.904E+06	1.976E+02	99.9362	99.5455
150 - 160	8.033E+00	3.034E+06	2.300E+02	99.9391	99.4848
160 - 170	4.378E+00	2.191E+06	2.652E+02	99.9470	99.4321
170 - 180	1.553E+00	1.464E+06	3.032E+02	99.9678	99.4002
180 - 190	9.863E-01	9.021E+05	3.441E+02	99.9624	99.3628

* denotes interpolated data values
E denotes scientific notation, e.g. : 1E06 = 1x10^6

CLASS	Rc	% CONTRIBUTION TO TOTAL LOSS
EGGS - 10mm	99.8057	30.4238
10mm - 30mm	99.9608	6.1279
30mm - 90mm	99.9872	1.9991
90mm +	99.6080	61.4491
TOTAL	99.3628	

Table V-11. Individual size class and summary size group R_c values developed for kelp bass (presented as a combination of kelp bass and barred sand bass) at El Segundo Generating Station Units 3 and 4.

SIZE CLASS (mm)	DAILY LOSS	FIELD ESTIMATE*	DAYS/CLASS	Rc	CUMULATIVE Rc
ENTRAINMENT					
EGGS	*	*	6.269E+00	99.9971	99.9971
2 - 3	3.394E+03	7.391E+08	5.999E+00	99.9973	99.9944
3 - 4	1.674E+02	4.628E+08	5.999E+00	99.9998	99.9942
4 - 5	1.320E+02*	2.284E+08	5.999E+00	99.9997	99.9938
5 - 6	1.320E+02*	4.031E+07	5.504E+00	99.9982	99.9920
6 - 7	1.320E+02*	1.044E+07	1.699E+00	99.9979	99.9899
7 - 8	1.320E+02*	1.413E+07	1.699E+00	99.9984	99.9883
8 - 9	1.320E+02*	4.307E+06	1.699E+00	99.9948	99.9831
9 - 10	9.663E+01	2.301E+06	1.699E+00	99.9929	99.9759
10 - 90	*	*	4.544E+02	99.7793	99.7553
IMPINGEMENT					
90 - 100	1.507E-02*	2.023E+06	7.178E+01	100.0000	99.7552
100 - 110	1.507E-02*	1.967E+06	7.393E+01	100.0000	99.7552
110 - 120	1.918E-02	1.905E+06	7.594E+01	99.9999	99.7551
120 - 130	1.370E-02	1.838E+06	7.784E+01	100.0000	99.7550
130 - 140	1.918E-02	1.767E+06	7.962E+01	99.9999	99.7550
140 - 150	1.918E-02	1.694E+06	8.132E+01	99.9999	99.7549
150 - 160	3.014E-02	1.619E+06	8.294E+01	99.9998	99.7547
160 - 170	7.123E-02	1.544E+06	8.448E+01	99.9996	99.7543
170 - 180	7.397E-02	1.469E+06	8.596E+01	99.9996	99.7539
180 - 190	1.342E-01	1.395E+06	8.738E+01	99.9992	99.7530
190 - 200	2.329E-01	1.321E+06	8.875E+01	99.9984	99.7515
200 - 210	2.822E-01	1.250E+06	9.007E+01	99.9980	99.7495
210 - 220	3.753E-01	1.180E+06	9.134E+01	99.9971	99.7466
220 - 230	4.740E-01	1.112E+06	9.258E+01	99.9961	99.7426
230 - 240	3.452E-01	1.047E+06	9.377E+01	99.9969	99.7395
240 - 250	2.521E-01	9.840E+05	9.493E+01	99.9976	99.7371
250 - 260	1.726E-01	9.235E+05	9.606E+01	99.9982	99.7353
260 - 270	1.096E-01	8.656E+05	9.715E+01	99.9988	99.7341
270 - 280	1.178E-01	8.102E+05	9.822E+01	99.9986	99.7327
280 - 290	6.849E-02	7.575E+05	9.926E+01	99.9991	99.7318
290 - 300	8.493E-02	7.074E+05	1.003E+02	99.9988	99.7306
300 - 310	6.849E-02	6.598E+05	1.013E+02	99.9990	99.7295
310 - 320	4.110E-02	6.148E+05	1.022E+02	99.9993	99.7289
320 - 330	5.479E-03	5.723E+05	1.032E+02	99.9999	99.7288
330 - 340	3.014E-02	5.321E+05	1.041E+02	99.9994	99.7282
340 - 350	5.890E-02*	4.943E+05	1.050E+02	99.9988	99.7269
350 - 400	8.767E-02	1.980E+06	5.381E+02	99.9976	99.7245

* denotes interpolated data values
E denotes scientific notation, e.g. : 1E06 = 1x10^6

CLASS	Rc	% CONTRIBUTION TO TOTAL LOSS
EGGS - 10mm	99.9759	8.7286
10mm - 30mm	99.9835	5.9891
30mm - 90mm	99.7958	74.1077
90mm +	99.9692	11.1746
TOTAL	99.7245	

Table V-12. Individual size class and summary size group R_c values for shiner surfperch at El Segundo Generating Station Units 3 and 4.

SIZE CLASS (mm)	DAILY LOSS	FIELD ESTIMATE	DAYS/CLASS	Rc	CUMULATIVE Rc
ENTRAINMENT					
IMPINGEMENT					
35 - 40	8.977E-01*	3.850E+05	6.873E+01	99.9840	99.9840
40 - 50	9.413E-01*	4.088E+05	1.375E+02	99.9684	99.9523
50 - 60	3.960E-01*	1.720E+05	1.375E+02	99.9684	99.9207
60 - 70	1.666E-01*	7.234E+04	1.375E+02	99.9684	99.8891
70 - 80	7.006E-02*	3.043E+04	1.375E+02	99.9684	99.8575
80 - 90	2.947E-02*	1.280E+04	1.375E+02	99.9684	99.8259
90 - 100	5.633E+00	2.754E+05	1.375E+02	99.7192	99.5456
100 - 110	1.732E+00	5.689E+05	4.271E+02	99.8701	99.4163
110 - 120	5.918E-01	2.648E+05	3.607E+02	99.9194	99.3362
120 - 130	4.082E-01	1.719E+05	4.181E+02	99.9008	99.2376

* denotes interpolated data values
E denotes scientific notation, e.g. : 1E06 = 1x10^6

CLASS	Rc	% CONTRIBUTION TO TOTAL LOSS
EGGS - 10mm	100.0000	0.0000
10mm - 30mm	100.0000	0.0000
30mm - 90mm	99.8259	22.7704
90mm +	99.4107	77.2296
TOTAL	99.2376	

Pacific Butterfish. Entrainment of Pacific butterfish at Units 3 and 4 represented 0.1% of total station entrainment (Chapter III, Table III-1). The species comprised 0.3% of total impingement collections (Chapter IV, Table IV-2). These levels are lower than those experienced by the species at the Units 1 and 2 intake. The R_c values developed for target species experiencing higher losses indicated that no adverse impact on those populations was expected. Loss levels of Pacific butterfish indicate that no significant adverse impact is expected.

Sargo. The species represented <0.1% of total station entrainment losses (Chapter III, Table III-1) and 0.5% of station impingement losses (Chapter IV, Table IV-2). Based on R_c values developed for species experiencing much greater losses, the impact of these levels of cropping on the nearshore sargo population is not considered significant.

Spotfin Croaker. No individuals of this species were entrained or impinged at Units 3 and 4 during the 316(b) study.

Bocaccio. No larvae of this species were observed in entrainment collections at Units 3 and 4 (Chapter III, Table III-1). A mean annual total of only 15 individuals were observed in impingement samples during the 316(b) study period (Chapter IV, Table IV-2), indicating no significant impact on the nearshore population.

Table V-13. Individual size class and summary size group R_c values for white surfperch at El Segundo Generating Station Units 3 and 4.

SIZE CLASS (mm)	DAILY LOSS	FIELD ESTIMATE	DAYS/CLASS	$\bar{R}c$	CUMULATIVE Rc
ENTRAINMENT					
IMPINGEMENT					
54 - 60	3.598E-02*	3.483E+05	3.672E+01	99.9996	99.9996
60 - 70	5.226E-02*	4.421E+05	6.120E+01	99.9993	99.9989
70 - 80	3.554E-02*	3.007E+05	6.120E+01	99.9993	99.9982
80 - 90	2.417E-02*	2.045E+05	6.120E+01	99.9993	99.9975
90 - 100	8.493E-01	4.902E+05	6.120E+01	99.9894	99.9868
100 - 110	7.507E-01	7.992E+05	1.101E+02	99.9897	99.9765
110 - 120	2.877E-01	7.167E+05	1.121E+02	99.9955	99.9720
120 - 130	3.397E-01	7.317E+05	1.317E+02	99.9939	99.9659
130 - 140	9.014E-01	7.209E+05	1.527E+02	99.9809	99.9468
140 - 150	1.011E+00	6.854E+05	1.753E+02	99.9742	99.9210
150 - 160	1.005E+00	6.287E+05	1.993E+02	99.9681	99.8891
160 - 170	1.529E+00	5.560E+05	2.249E+02	99.9382	99.8274
170 - 180	2.318E+00	4.738E+05	2.519E+02	99.8769	99.7045
180 - 190	2.153E+00	3.887E+05	2.803E+02	99.8448	99.5498

* denotes interpolated data values
E denotes scientific notation, e.g. : 1E06 = 1x10^6

CLASS	Rc	% CONTRIBUTION TO TOTAL LOSS
EGGS - 10mm	100.0000	0.0000
10mm - 30mm	100.0000	0.0000
30mm - 90mm	99.9975	0.5650
90mm +	99.5523	99.4350
TOTAL	99.5498	

Black Croaker. Larvae of black croaker comprised <0.1% of total entrainment collections at Units 3 and 4 (Chapter III, Table III-1). Additionally, the species comprised only 0.2% of total station impingement (Chapter IV, Table IV-2). These loss levels indicate that, even without the development of an R_c value, no adverse effect on the population was associated with operation of Units 3 and 4.

Yellowfin Croaker. A mean annual total of 11 individuals of this species were observed in impingement collections at Units 3 and 4 during the 316(b) study period (Chapter IV, Table IV-2). The species comprised <0.1% of entrainment collections during the same period (Chapter III, Table III-1) resulting in no impact on the nearshore population.

Black Surfperch. The viviparous mode of reproduction utilized by the surfperches precluded the entrainment of larvae at Units 3 and 4. The species comprised only 0.2% of total station impingement (Chapter IV, Table IV-2), a level of impact considered insignificant to the population.

Walleye Surfperch. Impingement levels of walleye surfperch at Units 3 and 4 was less than half that observed at Units 1 and 2, comprising 4.8% of total impingement collections (Chapter IV, Table IV-2). No larvae were taken in entrainment samples due to the viviparous mode of reproduction common to the surfperches. These levels of impact are considered insignificant to the walleye surfperch population.

A summary of R_c values, percent probability of mortality due to station operation, and level of impact on the population from the operation of ESGS Units 3 and 4 is presented in Table V-14.

Table V-14. Summary of station impact at El Segundo Generating Station Units 3 and 4.

Species	R_c	% Probability of Mortality Due to Station Operation $(1-R_c)$	Impact
northern anchovy	99.8144	0.1856	insignificant
white croaker	99.6742	0.3258	insignificant
queenfish	99.3625	0.6372	insignificant
kelp bass*	99.7245	0.2755	insignificant
shiner surfperch	99.2376	0.7624	insignificant
white surfperch	99.5498	0.4502	insignificant
Pacific butterfish	**	**	insignificant
sargo	**	**	insignificant
spotfin croaker	**	**	none
bocaccio	**	**	none
black croaker	**	**	insignificant
yellowfin croaker	**	**	none
black surfperch	**	**	insignificant
walleye surfperch	**	**	insignificant

* includes barred sandbass
** R_c values not developed due to low level of entrainment and/or impingement (see text)

Summary of Impact

Values of percent probability of mortality $(1-R_c)$ due to operation of ESGS (Tables V-7 and V-14) indicate that in no case was 0.8% of any species population affected. In most cases the calculated probability is a small fraction of one percent, and the impact on all 15 target species examined was found to be either insignificant or so low as to be negligible. Operation of the ESGS does not adversely affect the nearshore fish populations in the Southern California Bight.

VI. INTAKE TECHNOLOGY EVALUATION

Section 316(b) of PL 92-500 states that "... the location, design, construction, and capacity of cooling water intake structures reflect the best technology available for minimizing adverse environmental impact." As part of this 316(b) demonstration, SCE conducted an extensive evaluation of cooling water intake technology. The evaluation included a comprehensive literature review to identify and evaluate potential technologies, as well as field and laboratory tests to examine the applicability of specific technologies to the Pacific marine environment. The results of the literature review were provided in the Intake Technology Review Document (LMS 1982), and the results of the laboratory and field test programs were presented in the Larval Exclusion Study (LMS 1981). Results of the Larval Exclusion Study were also included in the Intake Technology Review document.

The review identified 28 intake technologies and summarized the information available on the engineering feasibility, biological performance (reduction of losses), and cost of each technology. This information and information on the general types and the operating environments of intakes within the SCE system were used to determine the potential applicability of each technology. Only those technologies for which the available information indicated a lack of engineering feasibility or low biological performance were removed from consideration as having no potential for application. Cost was not used as a criterion for elimination of any technology from further consideration. This conservative approach to the selection of technologies resulted in the classification as potentially applicable of some technologies which to date have not been demonstrated at operating marine cooling water intakes.

From the total of 28 technologies examined, nine were identified in the Review as potentially applicable to ESGS intakes. The applicable technologies are listed in Table VI-1 with estimates of the biological performance (fish loss reduction) for each of the four fish size categories examined in the Impact Analyses in Chapter V. The estimates of biological performance were based on the evidence collected in the Intake Technology Review and on laboratory and field tests with Pacific coastal species. Detailed descriptions of each of the technologies are given in the Intake Technology Review (LMS 1982).

Table VI-1. Performance (% survival compared to an offshore intake riser with no velocity cap) and cost estimates for alternative intake technologies at El Segundo Generating Station.

	Size Category (mm)				Costs $(10^6)	
Technology	0-10	10-30	30-90	>90	Units 1&2	Units 3&4
Porous Dike	0	50	75	90	97.7	97.7
Offshore Caisson	0	50	50	75	11.1	11.1
Velocity Cap						
Existing	0	0	0	90	0.5	0.5
Modified	0	0	0	91	1.0	1.0
Louvers	0	0	50	90	30.8	9.6
Angled Screens	0	50	75	90	30.8	7.8
Modified Vertical Traveling Screens	0	50	50	50	30.8	2.4
Flow Reduction	13	13	13	0	1.5	1.5
Intake Relocation to 22 m	*	*	*	*	73.5	73.5

* Varies with species; see Tables VI-9 and VI-10.

After the initial selections, each of the technologies listed in Table VI-1 was examined for site-specific applicability to the two ESGS intake systems. The hydraulic, structural, and operational requirements of each technology were compared to conditions in the existing structures to determine the feasibility of application. For each technology determined to be feasible, conceptual designs for retrofit were prepared from which estimates of the extent of structural and equipment modifications and associated costs were made (Table VI-1).

The benefit of applying each technology at ESGS was examined by determining the changes in levels of impact resulting from the reductions (or increases) in intake losses associated with operating each technology. The Impact Assessment Model was used, as described in the previous chapter, with intake losses adjusted according to the biological performance factors given in Table VI-1. The incremental change in the probability of survival was taken as the measure of the change in impact level achieved by each technology.

The applicability of each of the technologies to ESGS Units 1 and 2 and Units 3 and 4 intake systems is discussed below. The factors associated with the engineering feasibility and cost determinations, as well as the biological performance factors given in Table VI-1, are presented for each technology. The incremental change in impact levels is also presented for each technology and compared to costs.

The offshore intake velocity cap is discussed first, since it represents a technology already installed at both ESGS intakes. The impact levels resulting from the use of the velocity caps are compared to the levels associated with intakes with no velocity cap to show the incremental change in impact achieved by the velocity caps. The effects of applying the other technologies are subsequently examined relative to the impact levels determined for the velocity caps, since other technologies would be installed as additional systems and would affect only the losses occurring with the velocity cap in place.

SPECIFIC TECHNOLOGY EVALUATIONS

Velocity Cap

The engineering feasibility of the velocity cap in both the existing configuration at the ESGS intakes and the modified (expanded lip and cap) configuration was demonstrated in numerous installations (LMS 1982). The designs and costs of existing velocity cap structures in the SCE system were used to determine installation costs of both designs. The costs were taken as the additional costs to install a cap on an existing open pipe intake and to modify an existing standard cap. Although both ESGS Units 1 and 2 and Units 3 and 4 are equipped with standard velocity caps, the cost of the installation was included for comparison with other technologies.

The assessment of the biological performance of velocity caps was based on both prototype operating data and laboratory tests. Prototype data indicated the standard cap of the design at ESGS Units 1 and 2 and Units 3 and 4 reduced adult fish losses by approximately 90% relative to an intake with no velocity cap. Laboratory experiments indicated that the modified velocity cap with extended radius entrapped 10% fewer fish than the standard design. Thus, the incremental benefit of the modified cap is estimated to be about 1% for adult fish when each design is compared to an uncapped structure. Based on the limited perception and swimming abilities of larval and juvenile fish, no reduction in losses of fish less than 90 mm is attributed to the velocity cap. For the 30 to 90 mm class, this is conservatively low since some avoidance by fish at the upper limit of the size class is expected.

To examine the effect of the velocity caps, both existing and modified, the Impact Assessment Model was programmed with losses adjusted to reflect the performance factors associated with each design. The measured losses of adult fish (>90 mm) under existing conditions were increased for the "no velocity cap" situation and decreased for the modified design. The results of the analysis for the six species modeled are presented in Table VI-2 for both intakes. The table indicates the probability of survival, R_c (relative to 100% if the intake were not present), for each species assuming that no velocity caps were in place, the incremental improvement in survival achieved with the existing velocity caps, and the additional incremental improvement (relative to the existing velocity caps) projected for modified caps.

The results in Table VI-2 show that the incremental improvements in survival achieved by the existing caps range from 0 to 5.1% with the greatest improvements seen for shiner surfperch, white surfperch, and queenfish. The existing caps improve survival for shiner surfperch by 1.1 and 5.1%, respectively. This results in probabilities of survival of shiner surfperch for existing conditions of 99.9 and 99.2% for Units 1 and 2 and Units 3 and 4, respectively. The incremental improvements achieved by the modified velocity caps are less than 0.04% for all species except shiner surfperch, which show increments less than 0.06%.

Table VI-2. Incremental impact assessment for velocity caps.

Species	Survival without cap (%)*	Survival with cap (%)	Impact Change (%)	Survival with modified cap (%)	Impact Change (%)**
		EL SEGUNDO UNITS 1 AND 2			
queenfish	97.6746	99.6454	1.9708	99.6676	0.0221
kelp bass	99.5589	99.8332	0.2743	99.8363	0.0031
northern anchovy	99.8966	99.8966	-0-	99.8966	-0-
shiner surfperch	98.7190	99.8460	1.1270	99.8586	0.0126
white croaker	99.7704	99.8159	0.0419	99.8164	0.0005
white surfperch	97.7332	99.7689	2.0357	99.7917	0.0228
		EL SEGUNDO UNITS 3 AND 4			
queenfish	95.9112	99.3628	3.4516	99.4018	0.0390
kelp bass	99.4483	99.7245	0.2763	99.7276	0.0031
northern anchovy	99.8143	99.8144	0.0001	99.8144	-0-
shiner surfperch	94.0967	99.2376	5.1409	99.2963	0.0587
white croaker	99.6382	99.6742	0.0360	99.6745	0.0004
white surfperch	95.6095	99.5498	3.9403	99.5944	0.0446

* Survival = probability of survival relative to survival in absence of intake.

** Difference between velocity cap R_c and modified cap R_c.

These results show that the existing velocity caps reduce losses of adult fish to a point where the resulting deductions of the probabilities of survival, relative to the no intake situation, are less than 1.0% for all species. The existing caps significantly reduce the losses and resulting impact on adult queenfish. Given the low levels of impact achieved by the existing caps as described in Chapter V, the cost to achieve a small incremental improvement by modifying the caps is not justified.

Porous Dike

Since a porous dike has not been installed at any marine cooling water intake to date, the determination that it may be feasible at ESGS from an engineering standpoint is based on results of experimental studies and state-of-the-art knowledge of breakwater design and construction. Conceptual designs were prepared for installation of a porous dike in 30 ft (10 m) of water along the southern California coast (LMS 1979). This typical design is applicable to both ESGS Units 1 and 2 and Units 3 and 4 offshore intakes. The conceptual design was used as the basis for the cost estimate of $97.7 million; however, substantial additional study would be required before a final feasibility determination could be made.

The biological performance of a porous dike was determined from experimental data reported in the Intake Technology Review (LMS 1982) and the Larval Exclusion Study (LMS 1981). The low approach velocities and the physical barrier created by a dike is expected to effectively exclude adult fish of the species collected at El Segundo. Since the porous dike is an exclusion system, there is no mortality associated with the excluded fish. Due to the required size of the dike, small resident fish populations are expected to survive within the dike enclosure and be subject to impingement. Therefore, the expected biological performance is 90% for fish greater than 90 mm total length. This estimate is conservatively low for the purposes of impact assessment.

However, results of experiments with larval fish showed low avoidance of entrainment into a simulated dike, particularly for smaller larvae (LMS 1981). Avoidance was also reduced under low light conditions, indicating reduced performance for larvae at night. Based on the experimental evidence and the generally low perception and swimming abilities of larvae less than 10 mm in length, no reduction in larvae in this size category is attributable to the dike. A performance level of 50% exclusion of larvae between 10 and 30 mm was applied to the dike. In recognition of the difficulties of applying laboratory-scale test results to prototype design, this level is conservatively higher than the experimental data indicated. The 75% performance level for 30 to 90 mm fish recognizes the increasing avoidance by fish as their perception and swimming capabilities improve. As with the engineering evaluation, if further analysis indicates that the dike is a cost-effective technology, substantial additional investigation is required to clearly define its biological performance, particularly for larval and juvenile stages.

The changes in impact levels predicted for ESGS Units 1 and 2 and Units 3 and 4 intakes associated with a porous dike installation are given in Table VI-3. The changes represent the incremental effect of the dike on existing impact levels based on the previously discussed biological performance factors. With the exception of shiner surfperch, incremental improvements in the probabilities of survival for all other species are less than 0.5%. The incremental improvements for shiner surfperch range up to 0.7%. Given the high probabilities of survival (low impact) associated with the existing intakes (>99.2%), these small incremental improvements are not considered significant, particularly in relation to the $97.7 million cost of the dike.

Table VI-3. Incremental impact assessment for porous dike.

Species	Survival with Existing Technology (%)*	Survival with Modified Technology (%)	Impact Change (%)
	EL SEGUNDO UNITS 1 AND 2		
queenfish	99.6454	99.8582	0.2127
kelp bass	99.8332	99.9505	0.1173
northern anchovy	99.8966	99.9484	0.0517
shiner surfperch	99.8460	99.9804	0.1344
white croaker	99.8159	99.8682	0.0523
white surfperch	99.7689	99.9765	0.2076
	EL SEGUNDO UNITS 3 AND 4		
queenfish	99.3628	99.7438	0.3810
kelp bass	99.7245	99.9135	0.1890
northern anchovy	99.8144	99.9047	0.0930
shiner surfperch	99.2376	99.8974	0.6598
white croaker	99.6742	99.7641	0.0899
white surfperch	99.5498	99.9545	0.4047

* Survival relative to survival in absence of intake.

Offshore Caisson

Similar to the porous dike, the offshore caisson concept has not been utilized at an operating marine intake. Therefore, the engineering feasibility evaluation was based on proposed designs. A conceptual design for a caisson intake and access dock, located in 30 ft (9.1 m) of water off the southern California coast, was developed for use in cost determinations. The estimated cost to install caisson systems at El Segundo is $11.1 million for each intake. The design is applicable to both ESGS Units 1 and 2 and Units 3 and 4. Because of the lack of demonstrated performance of this technology, substantial additional study is necessary before a final feasibility determination is made. Whether such structures would be acceptable in terms of zoning, land use, and aesthetics is unknown at this time.

Since the caisson concept involves moving the intake screening apparatus offshore, the biological performance evaluation of the caisson intake is based primarily on the performance of modified vertical traveling screens with consideration given to the additional exclusion and return capability gained by the offshore location of the system. The combination of low approach velocities, the opportunity to avoid entrapment, and the short transport length of the fish return system leads to a projected biological performance rating for adult fish of 75%. The reduced swimming ability of larvae and juveniles in the two middle-length categories, which would negate the avoidance benefit, coupled with mortality from the impingement release system, result in the projection of 50% performance for fish between 10 and 90 mm in length. Low avoidance and high mortality of smaller larvae due to the impingement release system would result in no reduction of losses for larvae less than 10 mm in length.

The results of the incremental impact analysis for the offshore caission are given in Table VI-4. With the exception of shiner surfperch at Units 3 and 4, all incremental improvements in survival attributed to the cassion system are less than 0.4%. The incremental improvement for shiner surfperch at Units 3 and 4 is 0.5%. These increments are not considered significant in light of the low impact associated with the existing intakes.

Louver Guidance System

Louver guidance systems were determined to be a feasible technology for onshore screenwalls based on their use at existing hydropower sites and their

Table VI-4. Incremental impact assessment for offshore caisson.

Species	Survival with Existing Technology (%)*	Survival with Modified Technology (%)	Impact Change (%)
	EL SEGUNDO UNITS 1 AND 2		
queenfish	99.6454	99.8238	0.1784
kelp bass	99.8332	99.9175	0.0843
northern anchovy	99.8966	99.9457	0.0490
shiner surfperch	99.8460	99.9545	0.1085
white croaker	99.8159	99.8669	0.0510
white surfperch	99.7689	99.9416	0.1727
	EL SEGUNDO UNITS 3 AND 4		
queenfish	99.3628	99.6818	0.3191
kelp bass	99.7245	99.8579	0.1333
northern anchovy	99.8144	99.9024	0.0880
shiner surfperch	99.2376	99.7654	0.5278
white croaker	99.6742	99.7624	0.0882
white surfperch	99.5498	99.8866	0.3368

* Survival relative to survival in absence of intake.

inclusion in the design of San Onofre Unit 2 and Unit 3 intakes. The installation of louvers at ESGS Units 1 and 2 and Units 3 and 4 would, however, require extensive structural modification to the screenwells as well as installation of a fish return system to an offshore location.

In the case of the Units 1 and 2 intake, the existing screenwell is too small to accomodate the approach hydraulics or the length of required guiding louvers. The application of a louver guidance system would therefore require construction of a completely new screenwell structure. A further complication is the lack of sufficient area between the existing generating station structure and the shoreline to build a louver diversion-type screenwell. The estimated cost of $30.8 million in Table VI-1 for a louver guidance system at ESGS Units 1 and 2 is based on complete replacement of the existing screenwell, assuming that a suitable site could be determined.

The existing Units 3 and 4 screenwell is sufficiently large to accomodate a louver system, but would require extensive internal structural modification. Essentially, all internal walls and equipment would be removed and new structures put in place. In addition, the approach tunnel would need to be expanded vertically to provide proper approach hydraulics. The estimated cost of louvers for Units 3 and 4 is $9.6 million, based on these modifications to the existing structure.

The biological performance levels for louvers given in Table VI-1 are based on the performance of existing prototype louver systems with freshwater species and on laboratory tests with marine species common to the El Segundo area (LMS 1981, 1982). The test results indicate that high levels of diversion and return (90%) can be achieved for adult fish (>90 mm), but little or no diversion of larval fish less than 30 mm. The 50% performance estimate for 30 to 90 mm fish is based on the assumption that some portion of the larger fish in the size category will be diverted.

The results of reducing intakes losses by the performance factors determined for louvers are given in Table VI-5. With the exception of shiner surfperch, incremental improvements in the probability of survival are less than 0.5% for all species. The improvements for shiner surfperch are 0.1 and 0.6%. Given the low impact (probabilities of survival >99.2%) for all species with the present intake, these small incremental improvements are not significant, particularly in light of the $30.8 million and $9.6 million cost estimates for Units 1 and 2 and Units 3 and 4 intakes, respectively.

Table VI-5. Incremental impact assessment for louvers.

Species	Survival with Existing Technology (%)*	Survival with Modified Technology (%)	Impact Change (%)
	EL SEGUNDO UNITS 1 AND 2		
queenfish	99.6454	99.8469	0.2015
kelp bass	99.8332	99.9175	0.0843
northern anchovy	99.8966	99.9021	0.0055
shiner surfperch	99.8460	99.9734	0.1274
white croaker	99.8159	99.8212	0.0053
white surfperch	99.7689	99.9759	0.2070
	EL SEGUNDO UNITS 3 AND 4		
queenfish	99.3628	99.7211	0.3583
kelp bass	99.7245	99.8542	0.1297
northern anchovy	99.8144	99.8243	0.0100
shiner surfperch	99.2376	99.8539	0.6163
white croaker	99.6742	99.6799	0.0058
white surfperch	99.5498	99.9539	0.4041

* Survival relative to survival in absence of intake.

Angled Screens

The basic design requirements and layout of angled screen systems for onshore screenwells are similar to those for louvers. Therefore, the conclusions with regard to the structural modifications necessary at the ESGS screenwells are identical to those reached for louver systems, e.g., a new screenwell would be required at Units 1 and 2 and extensive modification would be necessary at Units 3 and 4. Also, both installations would require a fish return system. The cost estimates for angled screen systems at Units 1 and 2 and at Units 3 and 4 are $30.8 and $7.8 million, respectively.

The expected biological performance of angled screen systems in the ESGS screenwells is also similar to louver systems for adult fish (>90 mm). The angled screen systems, which can be fitted with fine mesh screening, would also be expected to remove some larval fish. Tests with marine larvae indicate that older larvae of hardy species could be diverted but young larvae showed low diversion and survival. These results, coupled with anticipated mortality resulting from the transport system, lead to estimated performance levels of 0% for larvae less than 10 mm and 50% return of larvae between 10 and 30 mm in length. The fine mesh will also increase diversion in the 30 to 90 mm size class from 50% for louvers to 75% for angled screens.

The impact reductions achieved by installation of angled screens are given in Table VI-6. The incremental improvements are similar to those for the louver system for all species and lead to the same conclusion that the high costs are not justified for the small changes (<0.7%) in impact.

Modified Vertical Traveling Screens

Two types of traveling screens were identified in the review as feasible for use in onshore screenwells: modified through-flow screens and center flow (single entry-double exit) screens. Both screen types have identical biological performance ratings but center flow screens are more expensive and require more extensive structural modification than the through-flow screens. Therefore, only modified through-flow vertical traveling screens are considered further in the technology evaluation.

For modified traveling screens to attain the estimated biological performance levels given in Table VI-1, the screenwell structure must provide evenly

Table VI-6. Incremental impact assessment for angled screens.

Species	Survival with Existing Technology (%)*	Survival with Modified Technology (%)	Impact Change (%)
	EL SEGUNDO UNITS 1 AND 2		
queenfish	99.6454	99.8582	0.2127
kelp bass	99.8332	99.9505	0.1173
northern anchovy	99.8966	99.9484	0.0517
shiner surfperch	99.8460	99.9804	0.1344
white croaker	99.8159	99.8682	0.0523
white surfperch	99.7689	99.9765	0.2076
	EL SEGUNDO UNITS 3 AND 4		
queenfish	99.3628	99.7483	0.3810
kelp bass	99.7245	99.9135	0.1890
northern anchovy	99.8144	99.9074	0.0930
shiner surfperch	99.2376	99.8974	0.6598
white croaker	99.6742	99.7641	0.0899
white surfperch	99.5498	99.9539	0.4041

* Survival relative to survival in absence of intake.

distributed approach flow with low tubulence at the screens. Because of a lack of sufficient room to expand the inlet tunnel flow to the full screenwell depth in the existing ESGS Units 1 and 2 screenwell, installing modified screens would require construction of a new screenwell structure. As discussed for both louver and angled screen systems, there is insufficient area available between the generating station and the shoreline for a larger screenwell. The estimated cost for the new screenwell is $30.8 million and additional costs may be incurred in relocating the screenwell. The Units 3 and 4 intake would require moderate internal modification and new screen systems at an estimated cost of $2.4 million. The costs for both intakes in Table VI-1 include an offshore fish return system.

The biological performance estimates for modified traveling screens were based on both prototype operation and laboratory tests with adults of fresh and estuarine species and laboratory tests with larvae of marine species (LMS 1981). The estimates consider the mortality caused by both the impingement and the return transport systems and also include consideration of the different species observed at ESGS.

The incremental changes in impact levels (probabilities of survival) given in Table VI-7 for modified traveling screens are all less than or equal to 0.4%, with the majority less than 0.1%. The impact changes for shiner surfperch are 0.1 and 0.4% for Units 1 and 2 and for Units 3 and 4 intakes, respectively. While modified traveling screens are the lowest cost alternative technology for Units 3 and 4 intake ($2.4 million), these costs are not justified by the low incremental reduction of the minimal impacts associated with the existing intake. By the same logic, the higher cost for lower levels of improvement at Units 1 and 2 ($30.8 million) is also not justified.

Flow Reduction

The advantages of employing flow reduction at existing intake cooling systems is the elimination of extensive construction at or below the water line. Flow reduction involves decreasing cooling water flow during hours of low demand, generally at night and early in the morning, when load requirements are reduced. An added advantage of this alternative is that these periods frequently exhibit highest rates of larval entrainment (SCE 1982a). The requirements for this alternative would be the installation of modified intake pumps at both Units 1 and 2 and Units 3 and 4. The cost estimates for implementing reduced flow are $1.5 million at each of the two intakes.

Table VI-7. Incremental impact assessment for modified vertical traveling screens.

Species	Survival with Existing Technology (%)*	Survival with Modified Technology (%)	Impact Change (%)
	EL SEGUNDO UNITS 1 AND 2		
queenfish	99.6454	99.7684	0.1230
kelp bass	99.8332	99.9099	0.0766
northern anchovy	99.8966	99.9457	0.0490
shiner surfperch	99.8460	99.9230	0.0770
white croaker	99.8159	99.8657	0.0498
white surfperch	99.7689	99.8844	0.1155
	EL SEGUNDO UNITS 3 AND 4		
queenfish	99.3628	99.5840	0.2212
kelp bass	99.7245	99.8502	0.1256
northern anchovy	99.8144	99.9024	0.0880
shiner surfperch	99.2376	99.6181	0.3805
white croaker	99.6742	99.7614	0.0872
white surfperch	99.5498	99.7746	0.2248

* Survival relative to survival in absence of intake.

The expected biological performance of flow reduction at ESGS was presented in Table VI-1. To meet cooling requirements and conform to engineering specifications of the modified pumps, flow could be reduced approximately 13% below present levels. This factor was incorporated into modified survival estimates (R_c) for flow reduction for life stages between egg and 90 mm length. No improvement in adult survival is assumed for reduced flow at ESGS.

The impact decreases achieved by flow reduction are presented in Table VI-8. No improvement was detected for either species of surfperch at either intake. The highest incremental improvements at Units 3 and 4 was observed for white croaker, but the change (0.04%) was extremely low. Other values at Units 3 and 4 ranged from 0.03 down to <0.001%, and all values at Units 1 and 2 were lower, consistent with the lower flow volume at that intake. The cost to achieve these small incremental improvements by installing modified pumping systems and reducing flow during non-peak hours is not justified.

Intake Relocation

The alternative of relocating the intake riser offshore at a depth of 72 ft (22 m) reflects on alternative intake location where densities of larval

Table VI-8. Incremental impact assessment for flow reduction.

Species	Survival with Existing Technology (%)*	Survival with Modified Technology (%)	Impact Change (%)
	EL SEGUNDO UNITS 1 AND 2		
queenfish	99.6454	99.6620	0.0166
kelp bass	99.8332	99.8502	0.0170
northern anchovy	99.8966	99.9096	0.0130
shiner surfperch	99.8460	99.8495	0.0035
white croaker	99.8159	99.8383	0.0224
white surfperch	99.7689	99.7692	0.0003
	EL SEGUNDO UNITS 3 AND 4		
queenfish	99.3628	99.3934	0.0306
kelp bass	99.7245	99.7551	0.0306
northern anchovy	99.8144	99.8376	0.0232
shiner surfperch	99.2376	99.2592	0.0216
white croaker	99.6742	99.7143	0.0401
white surfperch	99.5498	99.5501	0.0003

* Survival relative to survival in absence of intake.

and adult fish may be lower than that at the level of the present intake, and thereby yield a lower impact. This alternative would involve extending the intake conduit to a deeper depth contour, while utilizing the present velocity cap configuration. Costs for completing the relocation were estimated at $73.5 million per intake.

The expected biological performance of intake relocation varied by species and within size groups. An extensive breakdown of comparative concentrations of adults of six species (Table VI-9) and eggs and several size groups of larvae of those species (Table VI-10) was presented earlier. Only adult kelp bass were observed in comparable concentrations at the two depths (8 and 22 m); other species decreased in abundance at the deeper contours. Comparisons of egg and larval concentrations were based on data from the Bight-wide program (Lavenberg and McGowen 1982), and indicated that concentrations between adjacent size groups are highly variable.

Table VI-9. Projected adult loss factor* — effect of intake relocation to depth of 22 m.

Species	Factor
northern anchovy	0.2085
white croaker	0.2041
queenfish	0.7262
kelp bass	1.0000
white surfperch	0.1000
shiner surfperch	0.1972

* A factor of <1 indicates fewer adults at 22 m than at 8 m; a factor of >1 indicates more adults at 22 m.
Source: Wingert (1981)

The frequency of higher larval concentrations at 22 m, detailed in Table VI-10, was the significant factor in changes in R_c values for several target species. Values for kelp bass, northern anchovy, and white croaker all indicated increased impact due to intake relocation, expressed as negative values for "Impact Change" in Table VI-11. Changes were most evident for white croaker,

Table VI-10. Projected larval loss factor* — effect of intake relocation to depth of 22 m.

	Species					
Size Group (mm)	northern anchovy	white croaker	queenfish	kelp bass	white surfperch	shiner surfperch
Eggs	3.03	3.02	1.96	2.97	n/a	n/a
2- 3	3.03	0.60	1.40	2.97		
3- 4	2.89	7.52	1.09	9.25		
4- 5	2.71	4.50	0.14	109.0		
5- 6	5.09	6.80	<0.01	34.31		
6- 7	13.11	11.07	0.01	8.60		
7- 8	5.04	8.62	0.00	7.90		
8- 9	0.85	23.88		0.96		
9-10	2.87	26.80		0.71		
10-11	0.94	1.64				
11-12	2.14	6.53				
12-13	1.95					
13-14	1.11					
14-15	0.54					
15-16	1.47					
16-17	1.66					
17-18	0.40					
18-19	0.25					
19-20	0.18					
20-21	0.77					
21-22	1.29					
22-23	1.06					
23-24	0.48					
24-25	0.62					
25-26	0.52					
26-27	1.24					
27-28	7.24					
28-29	0.0					

* A factor of <1 indicates fewer larvae at 22 m than at 8 m; a factor of >1 indicates more larvae at 22 m.
Source: Lavenberg and McGowen (1982).

Table VI-11. Incremental impact assessment for intake relocation to depth of 22 m.

Species	Survival with Existing Technology (%)*	Survival with Modified Technology (%)	Impact Change (%)
	EL SEGUNDO UNITS 1 AND 2		
queenfish	99.6454	99.8295	0.1841
kelp bass	99.8332	99.7961	-0.0371
northern anchovy	99.8966	99.8863	-0.0103
shiner surfperch	99.8460	99.9696	0.1236
white croaker	99.8159	99.1023	-0.7136
white surfperch	99.7689	99.9769	0.2080
	EL SEGUNDO UNITS 3 AND 4		
queenfish	99.3628	99.6948	0.3320
kelp bass	99.7245	99.6581	-0.0664
northern anchovy	99.8144	99.7961	-0.0183
shiner surfperch	99.2376	99.8492	0.6116
white croaker	99.6742	98.3969	-1.2773
white surfperch	99.5498	99.9549	0.4051

* Survival relative to survival in absence of intake.

displaying values of -0.71 and -1.28%, respectively, at Units 1 and 2 and Units 3 and 4. Values for kelp bass and northern anchovy were much smaller, with a maximum change of -0.07% for kelp bass at Units 3 and 4. Both white croaker and northern anchovy have been observed to spawn in waters near 20 m depth, after which larvae migrate down into the water column and move inshore (SCE 1980).

In contrast, the incremental effect on queenfish and the surfperches was positive. Values of R_C increased up to 0.2 and 0.6%, respectively, at Units 1 and 2 and Units 3 and 4 (Table VI-11). The combination of high cost to achieve small incremental improvements for some species and the detrimental, although small, effects projected for others does not justify this alternative.

SUMMARY AND CONCLUSIONS

A comprehensive review and evaluation of cooling water intake technologies produced a list of nine technologies with potential applicability to marine intakes of the type used by SCE. Based on conceptual engineering designs for application of the nine technologies to each of the two ESGS intakes, the costs of applying technologies beyond the existing velocity caps range between $1.0 and $97.7 million for each intake. The incremental improvements in survival for alternative technologies are all less than 0.7%, with the majority less than 0.3%.

The existing intakes utilizing velocity cap technology are concluded to be best technology available (BTA). This determination is based on: 1) the ESGS does not have a significant adverse effect on the nearshore fish populations in the Southern California Bight; and 2) since probabilities of survival for all species were greater than 99.2% with the current velocity cap configuration, the existing intakes currently minimize any adverse impact, and the costs to achieve the extremely small incremental improvements in survival are not justified.

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APPENDICES

Appendix II-1. **Screenwell velocity measurements (fps) at El Segundo Generating Station Units 1 and 2 (Screen 1, north; total depth 14.4 ft).**

Depth (ft)	Channel	North Side Readings 1.0 sec Mean±S.D.	North Side Readings 10.0 sec Mean±S.D.	North Side Readings Range	Center Readings 1.0 sec Mean±S.D.	Center Readings 10.0 sec Mean±S.D.	Center Readings Range	South Side Readings 1.0 sec Mean±S.D.	South Side Readings 10.0 sec Mean±S.D.	South Side Readings Range
2	1	0.20±0.80	0.00±0.00	-0.5 - 1.5	-0.04±0.41	0.02±0.11	-1.5 - 0.2	0.32±0.13	0.74±0.09	-1.0 - 2.0
	2	0.84±0.50	0.98±0.13	0.5 - 2.5	0.00±0.00	0.00±0.00	-0.2 - 0.2	0.00±0.00	0.00±0.00	-1.2 - 1.0
6	1	-0.44±0.30	-0.04±0.09	-1.5 - 0.5	0.32±0.25	0.04±0.24	-1.0 - 1.0	3.36±0.50	2.76±0.17	0.0 - 6.0
	2	-0.22±0.11	-0.12±0.08	-1.0 - 0.8	-0.04±0.11	-0.06±0.13	-1.0 - 1.0	0.01±0.02	0.01±0.02	-1.0 - -1.0
10	1	-0.10±0.67	-0.28±0.11	-1.5 - 2.0	2.48±0.67	2.48±0.11	1.0 - 4.0	-0.12±0.90	-0.36±0.50	-2.0 - 2.0
	2	-1.08±0.72	-1.12±0.16	-3.0 - 0.5	-1.96±0.65	-2.00±0.14	-3.0 - -1.0	-0.28±0.28	-0.32±0.22	-2.0 - 2.5
14	1	0.42±0.13	0.10±0.21	-1.0 - 1.5	1.34±0.23	1.46±0.15	0.0 - 3.0	4.08±0.18	3.64±0.26	1.0 - 5.4
	2	-1.58±0.33	-0.70±1.12	-2.5 - 1.0	-1.26±0.19	-1.18±0.08	-3.0 - 0.0	-2.00±0.20	-0.32±1.66	-3.0 - 0.0
MEANS										
Vertical Transect	1	0.02	-0.06		1.02	1.00		1.91	1.70	
	2	-0.51	-0.24		-0.82	-0.81		-0.57	-0.16	
Screen Channel										
1 sec	1					0.98				
	2					-0.63				
10 sec	1					0.88				
	2					-0.40				

Source: LMS 1979

Appendix II-2. **Screenwell velocity measurements (fps) at El Segundo Generating Station Units 1 and 2 (Screen 2; total depth 14.4 ft).**

Depth (ft)	Channel	North Side Readings 1.0 sec Mean±S.D.	North Side Readings 10.0 sec Mean±S.D.	North Side Readings Range	Center Readings 1.0 sec Mean±S.D.	Center Readings 10.0 sec Mean±S.D.	Center Readings Range	South Side Readings 1.0 sec Mean±S.D.	South Side Readings 10.0 sec Mean±S.D.	South Side Readings Range
2	1	0.20±0.21	0.24±0.09	-2.5 - 2.5	0.76±0.26	1.08±0.08	0.0 - 3.0	-1.34±0.46	-0.80±1.23	0.0 - 3.0
	2	0.62±0.13	0.54±0.09	-0.5 - 1.8	2.54±0.22	2.58±0.08	-0.1 - 4.0	0.92±0.31	0.56±0.09	-2.0 - 3.0
6	1	4.72±0.39	4.52±0.18	2.0 - 6.0	4.24±0.26	3.84±0.17	3.0 - 6.0	-1.36±0.38	-1.30±0.12	-3.6 - -1.0
	2	1.76±0.36	1.80±0.00	1.0 - 3.0	2.88±0.23	2.76±0.09	1.0 - 4.0	1.58±0.28	1.16±0.17	0.0 - 3.0
**	1	4.24±0.46	4.36±0.33	2.0 - 6.0	3.44±0.26	3.44±0.36	2.0 - 5.0	-1.52±0.37	-1.66±0.11	-3.0 - 0.0
	2	1.32±0.18	1.48±0.18	0.0 - 3.0	3.60±0.14	3.48±0.11	2.0 - 5.0	1.32±0.30	1.78±0.04	0.0 - 4.0
MEANS										
Vertical Transect	1	2.46	2.38		2.50	2.46		-1.35	-1.05	
	2	1.19	1.17		2.71	2.67		1.25	0.86	
Screen Channel										
1 sec	1					1.20				
	2					1.72				
10 sec	1					1.26				
	2					1.57				

** Replication of readings at 6 ft depth

Source: LMS 1979

Appendix II-3. Screenwell velocity measurements (fps) at El Segundo Generating Station Units 1 and 2 (Screen 3; total depth 14.6 ft).

Depth (ft)	Channel	North Side Readings 1.0 sec Mean±S.D.	North Side Readings 10.0 sec Mean±S.D.	North Side Readings Range	Center Readings 1.0 sec Mean±S.D.	Center Readings 10.0 sec Mean±S.D.	Center Readings Range	South Side Readings 1.0 sec Mean±S.D.	South Side Readings 10.0 sec Mean±S.D.	South Side Readings Range
2	1	-0.22±0.20	0.14±0.24	-1.5 - -1.0	0.98±0.41	1.00±0.10	0.0 - 2.0	1.20±0.26	1.00±0.07	0.5 - 1.5
	2	0.05±0.31	-0.48±0.04	-1.0 - 0.6	-0.86±0.34	-0.72±0.13	-1.7 - 0.5	-0.48±0.11	-0.36±0.05	-1.0 - 0.0
6	1	-0.36±0.18	-0.28±0.38	0.2 - 1.0	0.06±0.75	0.38±0.20	1.0 - 1.5	0.84±0.68	0.94±0.17	0.0 - 2.0
	2	0.08±0.61	0.16±0.17	1.0 - 1.2	-0.42±0.29	-0.36±0.11	-1.5 - 1.5	-0.20±0.26	-0.10±0.10	-1.5 - 1.5
10	1	-0.44±0.40	0.18±0.15	-0.8 - 1.5	1.04±0.33	1.10±0.07	0.5 - 2.0	0.70±0.51	1.04±0.05	0.4 - 1.6
	2	-0.32±0.64	0.14±0.81	-1.6 - 1.0	-0.52±0.31	-0.70±0.07	-1.8 - 1.0	-0.16±0.21	0.86±0.23	-0.9 - 0.8
12	1	-0.12±0.32	-0.10±0.07	-1.4 - 1.2	1.06±0.17	1.12±0.04	0.5 - 2.0	0.86±0.23	0.76±0.09	0.4 - 1.6
	2	-0.64±0.32	-0.52±0.04	-1.5 - 0.8	-0.54±0.15	-0.66±0.05	-1.6 - 0.5	-0.06±0.21	-0.16±0.05	-0.9 - 0.8
MEANS										
Vertical	1	-0.28	-0.02		0.78	0.90		0.90	0.94	
Transect	2	-0.21	-0.18		-0.58	-0.61		-0.22	0.06	
Screen Channel										
1 sec	1					0.47				
	2					-0.34				
10 sec	1					0.61				
	2					-0.24				

Source: LMS 1979

Appendix II-4. Screenwell velocity measurements (fps) at El Segundo Generating Station Units 1 and 2 (Screen 4, south; total depth 14.6 ft).

Depth (ft)	Channel	North Side Readings 1.0 sec Mean±S.D.	North Side Readings 10.0 sec Mean±S.D.	North Side Readings Range	Center Readings 1.0 sec Mean±S.D.	Center Readings 10.0 sec Mean±S.D.	Center Readings Range	South Side Readings 1.0 sec Mean±S.D.	South Side Readings 10.0 sec Mean±S.D.	South Side Readings Range
2	1	0.04±0.34	0.16±0.05	-0.1 - 0.3	0.40±0.20	0.49±0.12	-1.0 - 0.2	0.69±0.15	0.63±0.03	0.4 - 0.9
	2	0.28±0.08	0.22±0.03	0.0 - 0.4	0.41±0.09	0.33±0.06	-0.4 - 0.6	0.18±0.11	0.12±0.04	-0.2 - 0.4
6	1	0.20±0.20	0.14±0.14	-0.2 - 0.6	0.54±0.15	0.52±0.08	0.2 - 1.0	0.82±0.26	0.72±0.08	0.5 - 1.2
	2	0.07±0.06	0.09±0.08	-0.6 - 0.5	-0.12±0.31	0.02±0.08	-0.4 - 0.6	-0.10±0.22	-0.26±0.09	-0.5 - 0.2
10	1	0.18±0.12	0.03±0.03	-0.2 - 0.8	0.32±0.18	0.33±0.05	0.0 - 0.8	0.66±0.15	0.63±0.09	0.2 - 0.8
	2	-0.15±0.35	-0.16±0.22	-0.4 - 0.3	0.12±0.19	-0.18±0.07	-0.8 - 0.4	-0.11±0.10	-0.06±0.03	-0.4 - 0.5
12	1	0.14±0.06	0.26±0.03	0.0 - 0.6	0.39±0.13	0.37±0.06	0.2 - 1.0	0.54±0.07	0.46±0.04	0.4 - 1.0
	2	-0.32±0.06	-0.20±0.05	-0.6 - 0.2	-0.36±0.22	-0.22±0.06	-0.8 - -0.1	-0.22±0.10	-0.06±0.14	-0.4 - 0.3
MEANS										
Vertical	1	0.14	0.15		0.43	0.43		0.68	0.61	
Transect	2	-0.03	-0.01		0.01	0.01		-0.06	-0.06	
Screen Channel										
1 sec	1					0.42				
	2					-0.03				
10 sec	1					0.40				
	2					-0.02				

Source: LMS 1979

Appendix II-5. Screenwell velocity measurements (fps) at El Segundo Generating Station Units 3 and 4 (Screen 1, north; total depth 13.6 ft).

Depth (ft)	Channel	North Side Readings 1.0 sec Mean±S.D.	North Side Readings 10.0 sec Mean±S.D.	North Side Readings Range	Center Readings 1.0 sec Mean±S.D.	Center Readings 10.0 sec Mean±S.D.	Center Readings Range	South Side Readings 1.0 sec Mean±S.D.	South Side Readings 10.0 sec Mean±S.D.	South Side Readings Range
2	1	0.66±0.17	0.88±0.13	0.4 - 1.2	0.78±0.15	0.80±0.00	0.6 - 1.1	0.98±0.13	0.92±0.08	0.6 - 1.4
	2	0.14±0.05	0.12±0.04	-0.1 - 0.3	0.06±0.09	0.04±0.05	-0.4 - 0.4	0.08±0.08	0.04±0.05	-0.4 - 0.6
6	1	0.96±0.11	1.02±0.08	0.5 - 1.3	1.00±0.14	0.92±0.04	0.6 - 1.3	0.96±0.11	0.84±0.09	0.3 - 1.2
	2	0.00±0.10	0.02±0.04	-0.3 - 0.3	-0.06±0.11	-0.04±0.05	-0.4 - 0.3	-0.04±0.15	0.11±0.07	-0.4 - 0.3
10	1	1.00±0.17	0.98±0.04	0.7 - 1.2	0.96±0.05	0.98±0.04	0.7 - 1.2	0.90±0.21	0.76±0.09	0.5 - 1.3
	2	0.06±0.11	0.08±0.13	-0.3 - 0.2	-0.02±0.04	-0.06±0.09	-0.3 - 0.2	0.14±0.09	0.02±0.04	-0.4 - 0.3
MEANS										
Vertical Transect	1	0.87	0.96		0.91	0.90		0.96	0.64	
	2	0.07	0.07		-0.01	-0.02		0.06	-0.01	
Screen Channel										
1 sec	1					0.91				
	2					0.04				
10 sec	1					0.90				
	2					0.01				

Source: LMS 1979

Appendix II-6. Screenwell velocity measurements (fps) at El Segundo Generating Station Units 3 and 4 (Screen 2; total depth 13.5 ft).

Depth (ft)	Channel	North Side Readings 1.0 sec Mean±S.D.	North Side Readings 10.0 sec Mean±S.D.	North Side Readings Range	Center Readings 1.0 sec Mean±S.D.	Center Readings 10.0 sec Mean±S.D.	Center Readings Range	South Side Readings 1.0 sec Mean±S.D.	South Side Readings 10.0 sec Mean±S.D.	South Side Readings Range
2	1	0.94±0.18	0.80±0.07	0.5 - 1.3	0.78±0.16	0.32±0.16	0.3 - 2.3	0.98±0.20	1.54±0.13	0.3 - 1.3
	2	0.02±0.16	-0.14±0.09	-0.4 - 0.2	-0.10±0.21	0.08±0.13	-0.8 - 0.4	0.18±0.25	0.04±0.11	-0.8 - 0.5
6	1	0.82±0.43	1.12±0.23	0.1 - 1.3	1.60±0.30	1.48±0.13	0.9 - 2.3	1.72±0.24	1.62±0.22	1.0 - 2.4
	2	-0.12±0.15	-0.04±0.05	-0.4 - 0.5	-0.04±0.13	-0.02±0.04	-0.9 - 0.6	-0.16±0.11	-0.06±0.05	-0.7 - 0.4
10	1	0.58±0.15	0.54±0.09	-0.3 - 0.8	1.14±0.11	1.14±0.09	0.2 - 1.3	0.94±0.19	1.16±0.09	0.7 - 2.4
	2	0.10±0.19	-0.02±0.04	-0.4 - 0.2	-0.14±0.11	-0.12±0.04	-0.7 - 0.5	0.00±0.23	-0.08±0.04	-0.6 - 0.7
MEANS										
Vertical Transect	1	0.78	0.82		1.17	0.98		1.12	1.44	
	2	0.00	-0.07		-0.09	-0.02		0.01	-0.03	
Screen Channel										
1 sec	1					1.02				
	2					-0.03				
10 sec	1					1.08				
	2					-0.04				

Source: LMS 1979

Appendix II-7. Screenwell velocity measurements (fps) at El Segundo Generating Station Units 3 and 4 (Screen 3; total depth 13.5 ft).

Depth (ft)	Channel	North Side Readings 1.0 sec Mean±S.D.	North Side Readings 10.0 sec Mean±S.D.	North Side Range	Center Readings 1.0 sec Mean±S.D.	Center Readings 10.0 sec Mean±S.D.	Center Range	South Side Readings 1.0 sec Mean±S.D.	South Side Readings 10.0 sec Mean±S.D.	South Side Range
2	1	1.04+0.15	1.02+0.08	0.7 - 1.3	0.94+0.15	0.94+0.11	0.7 - 1.3	1.04+0.11	1.18+0.04	0.7 - 1.3
	2	0.06±0.17	0.04±0.05	-0.3 - 0.2	-0.04±0.15	-0.08±0.04	-0.3 - 0.4	-0.10±0.10	-0.06±0.05	-0.3 - 0.1
6	1	0.86+0.13	0.92+0.04	0.6 - 1.3	0.94+0.17	0.92+0.04	0.7 - 1.3	1.18+0.11	1.12+0.04	0.9 - 1.4
	2	-0.10±0.10	0.04±0.05	-0.3 - 0.4	0.02±0.13	-0.10±0.00	-0.3 - 0.3	0.04±0.11	-0.04±0.05	-0.3 - 0.2
10	1	0.82+0.16	0.80+0.06	0.6 - 1.3	1.08+0.16	1.14+0.05	0.9 - 1.4	1.20+0.12	1.20+0.07	1.0 - 1.4
	2	-0.02±0.15	0.06±0.09	-0.3 - 0.3	0.08±0.11	0.02±0.04	-0.3 - 0.2	0.00±0.12	-0.06±0.09	-0.2 - 0.1
MEANS										
Vertical	1	0.91	0.91		0.99	1.00		1.14	1.17	
Transect	2	-0.02	0.05		0.02	-0.05		-0.02	-0.05	
Screen Channel										
1 sec	1					1.01				
	2					-0.01				
10 sec	1					1.03				
	2					-0.02				

Source: LMS 1979

Appendix II-8. Screenwell velocity measurements (fps) at El Segundo Generating Station Units 3 and 4 (Screen 4, south; total depth 14.3 ft).

Depth (ft)	Channel	North Side Readings 1.0 sec Mean±S.D.	North Side Readings 10.0 sec Mean±S.D.	North Side Range	Center Readings 1.0 sec Mean±S.D.	Center Readings 10.0 sec Mean±S.D.	Center Range	South Side Readings 1.0 sec Mean±S.D.	South Side Readings 10.0 sec Mean±S.D.	South Side Range
2	1	0.90+0.16	0.86+0.05	0.7 - 1.3	1.06+0.09	1.12+0.04	0.9 - 1.3	1.16+0.05	1.10+0.07	0.8 - 1.2
	2	0.02±0.04	0.04±0.05	-0.2 - 0.3	0.00±0.12	0.02±0.04	-0.1 - 0.3	0.02±0.08	-0.10±0.07	-0.2 - 0.2
6	1	1.00+0.12	1.10+0.00	0.8 - 1.3	1.00+0.16	1.08+0.04	0.8 - 1.3	1.16+0.11	1.08+0.04	0.8 - 1.4
	2	0.00±0.10	-0.04±0.09	-0.1 - 0.3	0.02±0.08	0.04±0.09	-0.2 - 0.2	0.04±0.09	-0.08±0.08	-0.3 - 0.1
10	1	0.92+0.19	0.80+0.07	0.6 - 1.4	0.88+0.16	1.00+0.07	0.5 - 1.3	0.86+0.17	0.94+0.05	0.7 - 1.4
	2	0.22±0.08	0.20±0.00	0.3 - 0.4	0.22±0.15	0.16±0.05	-0.4 - 0.2	0.06±0.11	0.02±0.08	-0.4 - 0.4
MEANS										
Vertical	1	0.94	0.92		0.98	1.07		1.06	1.04	
Transect	2	0.08	0.07		0.08	0.07		0.04	-0.05	
Screen Channel										
1 sec	1					0.99				
	2					0.07				
10 sec	1					1.01				
	2					0.03				

Source: LMS 1979

Appendix III-1 Ichthyoplankton entrainment abundance database at Ormond Beach Generating Station. Daily entrainment (number entrained X 10^5) from monthly samples.

Species	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Monthly Mean
northern anchovy	9.51	9.16	5.72	2.56	6.79	28.95	11.75	131.20	38.71	8.08	5.76	4.25	22.07
white croaker	--	--	0.07	11.82	4.39	8.25	29.83	92.13	44.19	22.55	0.56	--	17.84
queenfish	0.27	5.65	0.02	--	--	--	--	0.13	0.10	0.69	0.69	43.70	4.33
Pacific butterfish	--	0.02	--	--	--	--	--	0.32	<0.01	--	--	--	0.03
kelp bass	0.04	0.66	--	--	--	--	--	--	<0.01	--	--	--	0.06
barred sand bass	0.02	0.53	--	--	--	--	--	--	--	--	--	--	0.05
sargo	0.01	0.02	--	--	--	--	--	--	--	0.01	--	--	<0.01
spotfin croaker	--	--	--	--	--	--	--	--	--	--	--	--	--
bocaccio	--	--	--	--	--	--	--	--	--	--	--	--	--
black croaker	0.01	0.07	--	--	--	--	--	--	--	--	--	--	0.01
yellowfin croaker	--	0.04	--	--	--	--	--	--	--	--	--	--	<0.01
Pisces larvae, unid.	0.24	1.37	0.10	0.48	0.05	0.90	4.62	17.09	2.49	1.56	0.38	5.17	2.89
bay goby	0.69	13.30	2.63	0.92	0.19	0.80	0.61	0.13	0.22	0.07	0.14	0.02	1.63
Pisces yolk sac larvae	0.14	1.06	0.38	0.73	1.53	0.98	0.07	7.18	1.15	0.06	0.02	<0.01	1.12
cheekspot goby	0.46	1.58	0.58	0.84	0.13	1.20	0.61	0.12	0.52	1.39	1.03	3.82	1.03
goby type D	0.01	0.02	0.19	0.27	0.62	0.07	0.73	0.84	0.78	0.55	0.03	0.09	0.35
goby	0.09	--	0.24	0.13	0.04	0.43	0.58	0.04	0.04	0.26	0.29	1.08	0.27
California halibut/ fantail sole	0.09	0.60	0.01	0.09	<0.01	0.52	0.08	0.33	0.11	0.10	0.03	0.04	0.15
TOTAL LARVAE	12.24	37.89	10.70	19.27	14.35	42.76	49.40	250.32	89.08	35.63	9.19	58.51	52.75

Source: SCE 1982a

Appendix IV-1. **Monthly fish impingement at El Segundo Generating Station Units 1 and 2 from October 1989 through September 1980 (normal operation).**

	northern anchovy	white croaker	queenfish	Pacific butterfish	kelp bass	barred sand bass	sargo	spotfin croaker	bocaccio	black croaker	yellowfin croaker	shiner surfperch	black surfperch	walleye surfperch	white surfperch	number of collections
1978																
Oct	31	-	62	-	-	-	-	-	-	-	-	-	-	-	-	3
Nov	240	-	60	-	-	-	-	-	-	-	-	-	-	-	-	2
Dec	23	-	23	-	-	-	-	-	-	-	-	-	-	39	-	4
1979																
Jan	-	6	167	-	-	-	6	-	-	-	-	-	-	-	12	5
Feb	7	-	162	7	-	-	-	-	-	-	-	-	-	-	-	4
Mar	-	8	68	8	-	-	-	-	-	-	-	-	-	-	8	4
Apr	-	-	138	-	-	-	-	-	-	-	-	-	-	-	-	4
May	-	-	87	-	6	-	-	-	-	-	-	-	-	-	6	5
Jun	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3
Jul	-	-	30	-	-	-	-	-	-	-	-	-	-	-	-	2
Aug	-	7	53	-	-	-	-	-	-	-	-	-	-	-	10	9
Sep	-	4	8	-	4	-	4	-	-	-	-	-	4	8	4	8
Oct	3	17	160	67	7	-	-	-	-	-	-	-	-	13	17	9
Nov	-	5	55	5	-	-	-	-	-	-	-	-	-	70	5	6
Dec	-	1646	6069	183	251	48	3	-	-	3	-	668	62	6042	393	9
1980																
Jan	3	7	10	-	-	-	-	-	-	-	-	-	-	-	-	9
Feb	-	24	1484	-	-	-	-	-	-	-	-	16	4	120	52	7
Mar	-	-	442	-	-	-	-	-	-	-	-	54	-	23	58	8
Apr	-	3	15	-	-	-	-	-	-	-	-	3	-	9	-	10
May	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	8
Jun	-	-	73	-	-	-	-	-	-	-	-	4	-	-	4	8
Jul	-	-	109	-	3	-	-	-	-	-	-	-	-	-	-	10
Aug	-	-	-	-	8	-	-	-	-	-	-	-	-	-	-	4
Sep	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5
Total	307	1727	9275	270	279	48	13	-	-	3	-	745	70	6324	573	146

Appendix IV-2. **Monthly fish impingement at El Segundo Generating Station Units 3 and 4 from October 1978 through September 1980 (normal operation).**

	northern anchovy	white croaker	queenfish	Pacific butterfish	kelp bass	barred sand bass	sargo	spotfin croaker	bocaccio	black croaker	yellowfin croaker	shiner surfperch	black surfperch	walleye surfperch	white surfperch	number of collections
1978																
Oct	21	-	134	-	-	-	-	-	-	-	-	-	-	-	10	3
Nov	44	493	914	-	-	-	-	-	-	-	-	-	15	-	-	2
Dec	-	-	47	-	-	-	-	-	-	-	-	-	8	-	-	4
1979																
Jan	-	6	54	6	-	-	-	-	-	-	-	-	-	6	18	5
Feb	-	-	68	-	-	-	-	-	-	-	-	-	-	-	-	4
Mar	-	45	300	8	-	23	-	-	-	-	-	-	-	-	-	4
Apr	-	-	203	-	-	8	-	-	-	-	-	8	-	-	15	4
May	-	24	420	-	-	-	-	-	-	-	-	12	-	6	12	5
Jun	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	3
Jul	-	-	155	-	-	-	-	-	-	-	-	47	-	-	202	2
Aug	9	4	107	-	-	-	-	-	-	-	-	-	-	-	-	7
Sep	-	-	11	-	-	-	-	-	-	-	-	-	-	-	4	8
Oct	-	-	23	-	-	-	-	-	-	-	-	-	-	8	4	8
Nov	4	-	103	-	4	-	-	-	-	-	-	-	-	-	9	7
Dec	93	16	3457	70	31	19	-	-	-	-	4	4	47	744	1608	8
1980																
Jan	124	21	555	7	-	3	-	-	-	-	-	7	3	45	55	9
Feb	-	49	875	35	-	-	-	-	-	-	-	21	-	14	116	8
Mar	4	690	2100	23	-	-	-	-	-	4	4	1369	4	311	1553	8
Apr	-	3	579	6	-	-	-	-	-	-	-	-	3	-	-	10
May	-	-	4	-	-	-	-	-	-	-	-	-	-	-	4	8
Jun	-	-	30	-	-	-	-	-	-	-	-	-	-	-	-	8
Jul	6	-	84	-	-	-	-	-	-	-	-	3	-	9	-	10
Aug	-	-	16	-	-	-	-	-	-	-	-	8	-	-	16	4
Sep	-	-	23	-	-	-	-	-	-	-	-	-	-	-	-	5
Total	305	1351	10272	155	35	53	-	-	-	4	8	1479	80	1143	3626	144